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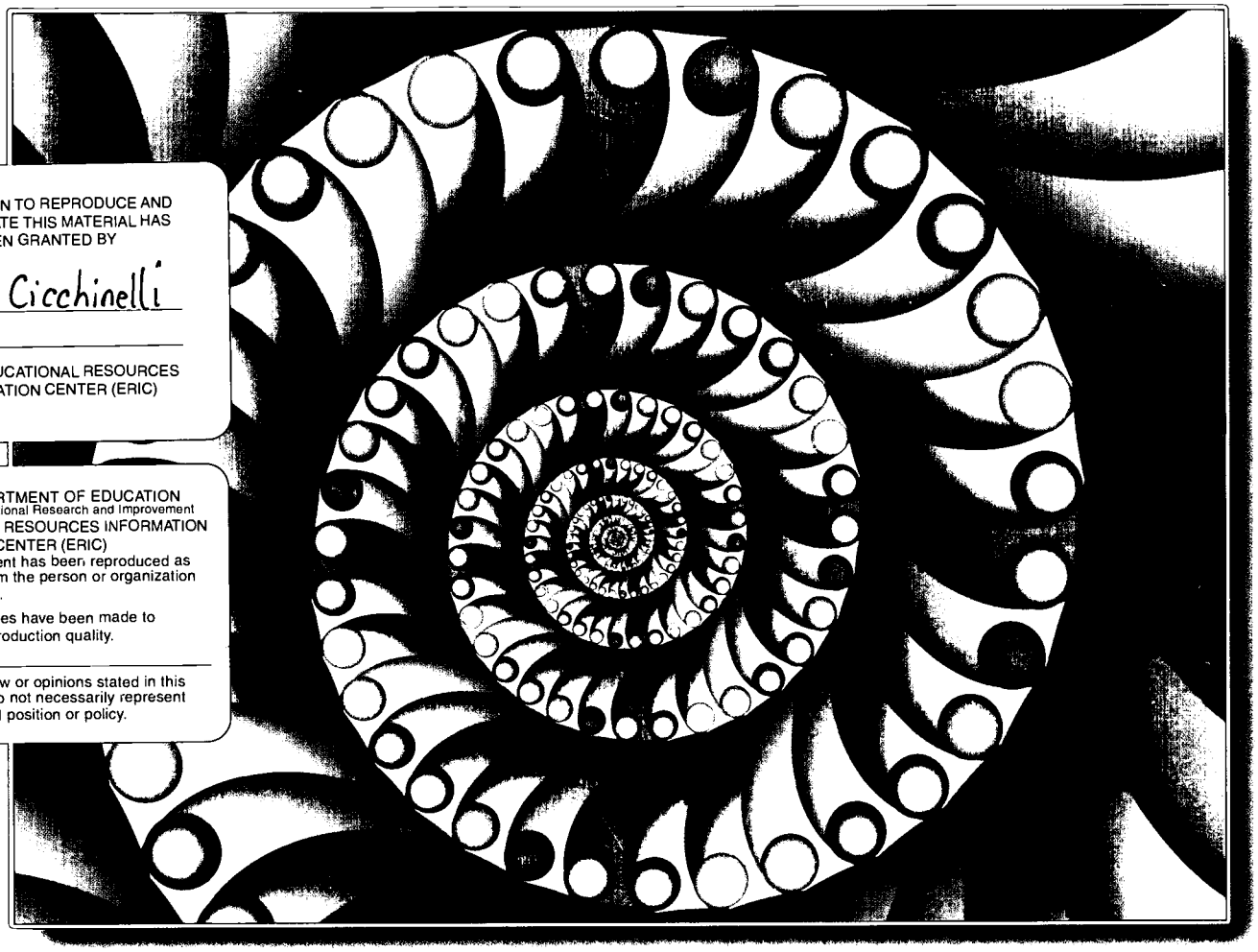
ABSTRACT

This publication helps identify ways in which high standards can be established and carried out in the classroom, discussing the importance of high standards and what has been learned from research about how teachers can help their students meet high learning goals. Chapter 1, "Introduction," examines the intent of standards, what has happened in the states regarding standards, and how teachers are the key to learning. Chapter 2, "The Keys to Literacy: Teaching Reading and Writing," discusses literacy standards, the standards-based curriculum, the importance of teacher knowledge, and effective classroom practices for literacy (e.g., balancing application and acquisition, tailoring instruction, and having meaningful conversations). Chapter 3, "Beyond Computation: Teaching Mathematics," examines mathematics standards, characteristics of an effective curriculum, the importance of teacher knowledge, and effective mathematics classroom practices (e.g., hands-on experience, meaningful classroom discussion, and supportive technology). Chapter 4, "Supporting Instructional Change," discusses professional development focused on standards, thinking systematically about improvement, short-term school improvement strategies, standards-based reform versus test-based reform, benefits of standards, and the future of standards. (Contains 139 references.) (SM)

Noteworthy *perspectives*

Teaching to the Core — Reading, Writing, and Mathematics



by

Helen S. Apthorp
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McREL

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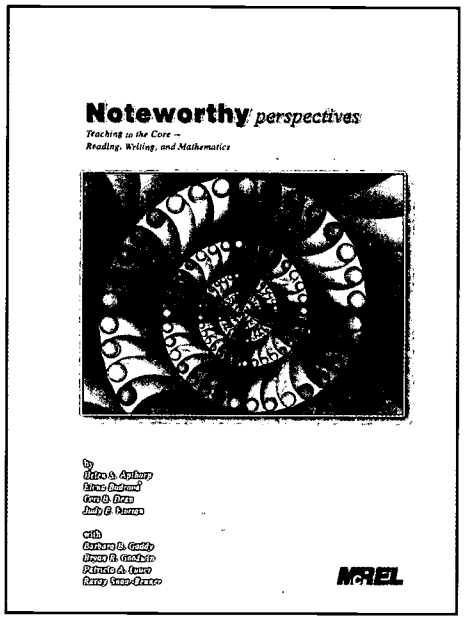
About The Cover



Look closely at the design on the cover of this *Noteworthy*. When you do, you may notice that each small part of it has a similar (but not necessarily identical) appearance to the full shape. The initial pattern repeats itself in various sizes and positions, based on a mathematical formula, and can increase dramatically in size and complexity. Mathematically, this pattern is known as a fractal. These days, fractal patterns are easily generated by computers rather than through laborious hand calculations and plotting.

Another interesting thing about fractals is that even the smallest change in the numbers in the formula can completely change what happens with each repetition of its use. We think the same is sometimes true of teaching – the smallest change can have an enormous effect on the final outcome.

Take a moment to examine the other fractals you will find throughout this issue.

Fractal images courtesy of Paul W. Carlson at http://www.mbfractals.com.

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PREFACE

The Mid-continent Research for Education and Learning (McREL), located in Aurora, Colorado, is a private, nonprofit organization founded in 1966 whose purpose is to improve education through applied research and development. McREL provides products and services, primarily for K–12 educators, to promote the best instructional practices in the classroom.

This publication was created through McREL's contract with the U.S. Department of Education's Office of Educational Research and Improvement (OERI) to serve as the regional educational laboratory for the states of Colorado, Kansas, Missouri, Nebraska, North Dakota, South Dakota, and Wyoming. As the recipient of this contract, McREL provides field-based research, technical assistance, professional development, evaluation and policy studies, and information services to state and local education agencies in these states.

For more than a decade, McREL has been in the forefront of research, practice, and evaluation related to standards-based education. As part of our recent regional laboratory contract, we were awarded standards-based classroom instruction as our national leadership area. This publication represents part of our continuing effort to build on our prior experience and current expertise, collaborate with key organizations, and work with schools, districts, and states to improve their practices and capitalize on the great potential that standards-based education holds for students.

This issue of *Noteworthy* is based on an analysis of the most current research available on reading, writing, and mathematics instruction. The advice, guidance, and suggested practices and strategies offered are based in part on *Standards in Classroom Practice: Research Synthesis* (Sanders, 2001), a synthesis of research on effective standards-based practices compiled by researchers Helen S. Apthorp, Judy E. Florian, Patricia A. Lauer, and Ravay Snow-Renner.

In addition to more detailed discussions of research concerning classroom practices in reading, writing, and mathematics, the synthesis describes current research about the professional development experiences that can help teachers learn what they need to know and do to carry out these practices. Finally, the synthesis describes the organizational capacity needed for teachers to carry out their work and for students to meet standards. Based on the complexity and challenge in helping teachers learn and carry out needed practices in classrooms, organizational capacity becomes a critical component of standards implementation.

This issue of *Noteworthy* represents the work of a team of individuals. In particular, the authors wish to acknowledge the contributions of several other McREL staff members. Clare Heidema offered her considerable knowledge from years of working in the field and studying effective instruction to guide the development of this publication. Vicki Urquhart developed some of the supporting materials and examples contained in these pages. Dawn McGill, Marina Farrell, and Tony Alberico created this publication's layout and design, with assistance from Marla Fultz. In addition, McREL's Deputy Director Lou Cicchinelli offered valuable guidance and insights throughout the development of this publication. We hope readers will find this issue of *Noteworthy* to be a useful tool as they carry out the ambitious mission of helping all children achieve high standards for learning.

Chapter 1 INTRODUCTION

This issue of *Noteworthy* is designed to help identify ways in which high standards can be established and carried out in the classroom. Toward this end, we discuss, first, the importance of high standards and, second, what we have learned from research about how teachers can help their students meet high learning goals. The guiding question of this issue is, What conditions are necessary to create schools and classrooms in which all students are capable of meeting high standards? Particular emphasis is given to mathematics, and reading and writing instruction.

The abilities to read and write and use mathematics are essential to success in school and in life. Not surprisingly, many state accountability systems focus on these areas as initial areas to be monitored. In offering a research-based response to the question about what classroom practices and conditions are needed to ensure that all students meet high standards, Chapters 2 and 3 focus on these areas. They also describe examples of how schools have created these conditions or adopted these practices.

Chapter 4, the concluding chapter, notes that teachers need a great deal of support in order to adopt effective practices in their classrooms. Professional development must focus on providing teachers with better methods of instruction in specific content areas. Chapter 4 also offers some insights from research about where schools might choose to begin their efforts to use standards as a means to improve student achievement. It acknowledges that creating effective standards-based schools is a lengthy and difficult process – one that requires systemwide changes.

THE INTENT OF STANDARDS

More than a decade ago, when uniform standards began to alter the landscape of American education, they were touted as a means of ensuring that all students reach high levels of learning. Proponents of standards argued that the problem wasn't that schools had no standards, but rather that they had implied standards, which were unevenly applied to students. In short, even though high standards may have been in place, there were high expectations for some students and low expectations for others. As a result, too many students were slipping through the cracks – moving through the system without mastering even core knowledge and skills needed for success.

Standards advocates believed that clearly articulating what students should know and be able to do would remove ambiguity from all levels of education. In so doing, it was expected that high standards accompanied by high expectations for all students would pull them – and, indeed, the entire country – out of what the 1983 report *A Nation at Risk* (National Commission on Excellence in Education) called "a rising tide of mediocrity."

WHAT HAS HAPPENED

Forty-nine states have now established state content standards, one state (Iowa) requires local standards, and all 50 have developed or are in the process of developing state assessment strategies to measure students' performance against standards (Education Week, 2001a). At the local level, districts are drafting standards and aligning curricula and assessments to them, and teachers are being asked to align their instruction with standards as well. As a result, standards are beginning to serve as a foundation for designing new classroom curricula as well as assessment and accountability systems in districts and states across the country.

Without a doubt, standards have become intricately intertwined with many other policy trends, such as high-stakes testing, accountability, and school takeovers. As a result, the term *standards* has taken on a wide variety of meanings – some of which have negative connotations.

> ***There have been numerous calls for educators and policymakers to revisit the original purposes for creating standards.***

Many assessment and accountability systems, intended to raise standards, have come under fire. The criticism is particularly vocal when the stakes are high – such as when students may be held back a year or denied a diploma based on test results. For example, in February 2000, nearly 200 Chicago students organized a "flunk-in" to protest the state's standards-based test. In March 2000, a group of high school students in Massachusetts boycotted a statewide assessment. And in December 2000, the California State Board of Education, fearing legal challenges to the state's new high school exit exam, voted to request urgent legislation delaying the date that the test becomes mandatory for students (Shafer, 2000).

But these protesters may not be so much against standards themselves as they are against the way learning is assessed by schools, teachers, and students. Although the intent was that standards would guide curricula and assessments, it can be argued that few curricula or assessment systems are actually standards based. As Panasonic Foundation executive Scott Thompson (2001) put it in a *Phi Delta Kappan* article, the original standards movement appears to have been supplanted in many cases by an "evil twin" of "high-stakes, standardized, test-based reform" – a movement characterized by reliance on a single assessment to judge student progress, rather than higher expectations for students. Thompson argues:

> When academic progress is judged by a single indicator and when high stakes – such as whether a student is promoted from one grade to the next or is eligible for a diploma – are attached to that single indicator, the common effect is to narrow curriculum and reduce instruction to test "prepping." What gets lost when teachers and students are pressured to make students better test-takers is precisely the rich, high-level teaching and learning that authentic, standards-based reform aims to promote in all classrooms and for all students. (p. 358)

At the same time, the creation of standards and the implementation of standards-based reforms have been such an enormous and complex undertaking that it's been easy for those involved in the movement to lose sight of the original purposes for creating standards. For many educators, standards have become yet another top-down mandate with which they must comply – items to be checked off in the "completed" column, rather than the foundation for creating learning environments that set and help students meet high standards.

In light of these concerns, there have been numerous calls for educators and policymakers to revisit the original purposes for creating standards. One very public call to action was made by Kati Haycock, executive director of the Education Trust, a nonprofit group that advocates for improving academic opportunities for students, especially those of color or from low-income backgrounds. Haycock has urged policymakers and educators to stay the course with standards, which she views as holding untapped promise for at-risk students. In Haycock's (2001) open letter to President George W. Bush, she urged him to "always make it clear that you believe that poor children and children of color can achieve at high levels if they are taught at high levels and get help along the way." At the same time, she asked the President to keep in mind that "teachers matter more than anything. If we want them to succeed with all children, we must invest generously in the kind of focused, coherent professional development that has fueled dramatic growth in student achievement in places like Connecticut and New York's District 2."

In step with this thinking, this issue of *Noteworthy* focuses not on policy issues or top-down changes, but on teachers and school leaders – and what they can and need to do to recapture the original intent of standards. The following chapters identify and describe practices and strategies that research indicates may be effective in accomplishing the primary goal of the standards movement – to set high learning goals for students and help them achieve those goals. And these chapters focus on making changes where we know they matter most – in the classroom.

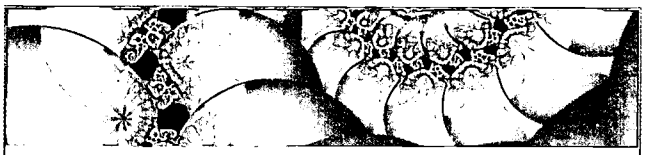
TEACHERS ARE THE KEY

If there is one thing we have learned over the past three decades of reform and research, it's that teachers matter most in schools. Standards and assessments are part of the puzzle, as are the availability of quality resources, a strong school/community partnership, and safe facilities. But teachers and teaching have a significant effect on student achievement. Tests don't improve student learning, teachers do. A curriculum alone doesn't improve student learning. But teacher-guided student interactions with the curriculum and teacher selections of elements for discussion, expansion, and emphasis do. High standards alone don't improve student learning. But teachers who communicate high expectations by providing intellectually challenging learning activities and materials do.

Now that standards have been written, assessments created, and accountability systems put in place, the implementation of standards-based reform essentially rests in the hands of teachers and school leaders.

But for teachers who are already experiencing intensification in their work, making the numerous changes required by standards can be frustrating if they don't see the bigger picture about the purpose of standards. As a result, it is clear that implementing standards in the classroom is more than just a technical matter. We hope that this issue of *Noteworthy* can help provide teachers, in particular, with insights into how they can change their instructional practices so that we can realize the original intent of standards-based education – that no child is left behind.

Chapter 2 THE KEYS TO LITERACY: Teaching Reading and Writing



In This Chapter

- Characteristics of an effective standards-based literacy curriculum
- The knowledge and skills that a literacy curriculum should cover
- Characteristics of exemplary literacy teachers
- The importance of having students apply their emerging knowledge
- The benefits of systematic phonics instruction
- Strategies for tailoring instruction to meet students' learning needs
- The benefits of teaching processes and engaging students in substantive conversations
- Using assessment as a prevention and intervention tool

The value of literacy has never been greater than it is today. As society continues to shift from an agrarian and industrial economy to an information-based economy, literacy has become essential to life success. Statistics show that a high percentage of people with low literacy skills live in poverty and that people with low literacy skills are more likely to be unemployed.

Given the importance of literacy, creating a literate citizenry is one of the primary goals of American public education. Citizens need to be able to read textbooks, newspapers, and primary source materials with understanding, learn and integrate new information from multiple sources, and write and communicate ideas with confidence. Evidence, however, suggests that this goal is not being realized. For example, nearly 40 percent of fourth graders on the most recent National Assessment of Educational Progress (2001) did not demonstrate understanding of the overall meaning of what they read, scoring in the "below basic" range, the lowest of four ranges (advanced, proficient, basic, below basic). And from 1992 to 2000, while the highest performing fourth-grade students made steady gains in reading, the lowest performing students lost ground, demonstrating lower and lower performance on the fourth-grade NAEP reading assessment.

Of particular concern is the plight of children from low socioeconomic (SES) homes. Whitehurst and Lonigan (1998) found that many of these children attended and benefited from high-quality early childhood programs, but then experienced a significant deceleration in their reading performance when they entered first grade in a school primarily serving low-SES children. Moreover, research shows that gaps in reading achievement related to socioeconomic differences continue to widen in the intermediate and higher grades (Chall, 1996; Snow, Barnes, Chandler, Goodman, & Hemphill, 1991).

Since 1992, gaps in performance between white and African American students and between white and Hispanic students have not changed. In 2000, average NAEP fourth-grade reading scores for African American, Hispanic, and American Indian students fell below the 50th percentile, while the same scores for white students fell above the 50th percentile (Phillips, 2001). It should be noted, however, that these results do *not* indicate that racial differences in any way explain achievement differences. In fact, differences in achievement related to race or ethnicity mask relationships between socioeconomic status and achievement. Of the fourth-grade students eligible for free or reduced-price lunch, 14 percent performed at or above proficiency in NAEP reading compared to 41 percent of students not eligible (Phillips, 2001).

These achievement gaps in reading, disturbing as they are, are sometimes made worse by what happens in classrooms. For example, studies have found (see, e.g., Duke, 2000) that the total number of books, and informational books in particular, is significantly fewer in first-grade classrooms at schools in low-SES neighborhoods compared to those in mid- to high-SES neighborhoods. Vocabulary assignments are often limited to copying sentences rather than analyzing meaningful attributes and relationships (Valdes, 1998); and, many teachers only tell about or check comprehension rather than demonstrate, explain, and coach how to read for understanding (Snow et al., 1991).

To address these problems and to improve the educational opportunities and achievement of students with high academic needs, a number of federal programs and reform efforts have been designed. In addition to the compensatory education programs of Title I that began with the Elementary and Secondary Education Act in 1965, in 1989 the first National Education Summit was held, which led to the establishment of a set of national education goals. These goals firmly and clearly stated that reaching challenging standards was expected of all students. State and federal assessments of student achievement were subsequently implemented to hold educators and schools accountable for meeting these expectations.

The establishment of clear and common learning targets for all students, however, only begins to address the inequities in public education. Educators need to understand – and then implement – the conditions and classroom practices that allow teachers to help all students reach challenging standards. This issue of *Noteworthy* responds to this need.

This chapter begins by addressing the problem of helping all students become literate. It discusses what literacy is and how it is defined in standards documents and by literacy educators. The chapter then draws on a range of research literature, including case studies of exemplary literacy teachers and literacy practices in high-performing, high-needs schools to identify the most promising classroom practices and conditions for helping all students become literate.

LITERACY STANDARDS: DESCRIBING THE VISION

Literacy is the ability to read and write meaningfully and with understanding. In its 1999 publication, *Reading & Writing Grade by Grade*, the New Standards Primary Literacy Committee describes "the ultimate goal of reading" as "getting the meaning" (p. 19). A literate person perceives the meaning, the significance of a phenomenon, the substance, the main ideas, and the relevant details in a book, article, technical manual, poem, or Web page. Literacy also encompasses the ability to communicate in writing the essence of an idea, experience, or emotion so that a specific person, group of people, or multiple audiences can understand the point.

> ***Literacy is the ability to read and write meaningfully and with understanding.***

A literate person also continually enhances his or her reading and writing skills. To continue to learn requires metacognition, the awareness and ability to control one's thinking. The metacognitive goal of literacy is to develop and use productive habits of mind, one aspect of which is hypothesizing patterns and principles for describing how the world and languages work. A primary goal of K–12 education should be to help students become more and more knowledgeable and reflective users of language.

Standards that define expectations for learning to read and write meaningfully and with understanding are found in state and national standards documents. In 1996, the National Council of Teachers of English (NCTE) and the International Reading Association (IRA) jointly produced *Standards for the English Language Arts*, which includes 12 content standards identifying key knowledge, skills, strategies and dispositions for reading, comprehending and interpreting, writing, conducting research, and communicating. These standards are intended for all students, kindergarten through grade 12, regardless of their stage of development, and are meant to build on the "emerging literacy abilities that children bring to school" (p. 3).

Although the standards identified in *Standards for the English Language Arts* are meant to apply to all students across grades K–12, this document does not identify benchmarks – statements of the knowledge and skills that students should acquire at various developmental levels, for example at the end of individual grades or at the end of a grade span (e.g., K–2). Only recently have national groups of leading researchers and educators agreed on developmentally appropriate benchmarks in literacy.

In particular, primary grade literacy standards were written and published in 1999 by the New Standards Primary Literacy Committee in *Reading & Writing by Grade: Primary Literacy Standards for Kindergarten through Third Grade.* These standards and benchmarks specify grade by grade the knowledge and skills that are more broadly stated in *Standards for the English Language Arts.* The members of the New Standards Primary Literacy Committee were literacy experts with differing views on best practices and programs for teaching literacy, especially with regard to the appropriateness of "phonics" versus "whole language." Nonetheless, they were determined, as they noted in this publication, "not to paper over differences with vague words but instead lay out clearly the full range of skills, knowledge and literacy habits that primary children need to learn if they are to succeed in later schooling and life" (p. 8). As a result, *Reading & Writing Grade by Grade* successfully focuses on what children should know and be able to do, rather than on ideologies or philosophies underlying specific instructional programs.

Other sources of primary grade literacy benchmarks are found in the research literature. In particular, *Preventing Reading Difficulties in Young Children*, a National Research Council report (Snow, Burns, & Griffin, 1998), provides a table of typical accomplishments made by children who successfully learn to read and write, which are synonymous with grade-level literacy benchmarks for kindergarten, first, second, and third grade. These primary grade accomplishments include foundational skills and knowledge (i.e., phonemic awareness, phonics, word identification, and sight vocabulary) as well as the skills, knowledge, and dispositions customarily associated with reading and writing for meaning (e.g., fluency, vocabulary, comprehension, composition, and motivation).

Statements about what children should know and be able to do in literacy can also be found in frameworks for national assessments, both produced by the National Assessment Governing Board: the *Reading Framework for the National Assessment of Educational Progress: 1992–2000, NAEP Reading Consensus Reading Project* (2001a) and the *Writing Framework and Specifications for the 1998 National Assessment of Educational Progress* (2001b). Other literacy documents include a series of publications developed by the New Standards project (1997a, 1997b, 1997c), which specify performance standards across elementary, middle, and high school, and the NCTE-published *Exemplars* series (e.g., Myers & Spalding, 1997), which provides exemplars of student work in reading and writing at different levels of performance.

Literacy standards, benchmarks, and exemplars represent a broad range of knowledge and skills that serve multiple purposes, including reading for personal fulfillment and to acquire new information and knowledge, and writing effectively to communicate and to explore ideas. Developing insights about language and understanding language and print concepts also are clear expectations in these documents. All statements about the knowledge and skills students should acquire and develop

emphasize, however, the *application* of language knowledge rather than merely its *acquisition.*

As an application of language knowledge, literacy involves the ability to build on prior knowledge. The New Standards Primary Literacy Committee (1999) describes this process when it writes that "people get smarter when they read; they learn the words, references and concepts that are the foundation for the next ideas they will encounter and learn. The more you know, the more you can learn" (p. 23). Similarly, the committee maintains, writing helps integrate and crystallize knowledge, helping writers "discover new meaning" (p. 31).

Nationally recognized literacy documents describe high standards for students. But, as described in the NCTE/IRA's *Standards for the English Language Arts* (1996), students who reach these high standards are more likely to be able to "participate as knowledgeable, reflective, creative, and critical members of a wide array of literate communities" (p. 3). Classroom practices that can help all students reach these standards are addressed in the next sections.

THE STANDARDS-BASED CURRICULUM

Literacy experts, researchers, and experienced educators know that students' learning of the body of knowledge defined by standards depends in part on the curriculum they experience. A standards-based literacy curriculum should help students become literate. Research demonstrates that a curriculum that enables students to reach high literacy standards has the following characteristics:

- Balanced
- Has a developmental scope and sequence aligned with standards and benchmarks
- Can be customized
- Is comprehensive

A standards-based curriculum is *balanced.* Short (1999) proposes a view of a balanced literacy curriculum that equally emphasizes three aspects of interactive language learning:

- Learning about language, which involves looking at language itself (e.g., learning how language works)
- Learning through language, which involves learning about the world and oneself through reading and writing
- Language learning, which involves learning to read, speak, and write by reading, speaking, and writing (i.e., emphasizing application, not just acquisition)

Another feature of a standards-based, literacy curriculum is that it *has a developmental scope and sequence that is aligned with standards and benchmarks.* Aligning a curriculum with grade-level or end-of-grade-range (e.g., K–2) benchmarks helps ensure that students develop key competencies within reasonable periods of time at critical points in their schooling. Prerequisite knowledge, skills, and experiences are presented prior to more complex or abstract knowledge, skills, and experience. Likewise, new material connects to and builds on prior experiences and knowledge students have gained.

A third feature of a standards-based, literacy curriculum is that it *can be customized.* Effective teachers need access to a curriculum that can be modified in order to teach children at their appropriate developmental levels. For example, if there are a number of children who need practice with phonics, teachers might develop assignments that include such activities as playing computer games or sorting objects or pictures by beginning sound(s). When a school does not provide a curriculum that can be customized, which may be the case if a curriculum that is age driven rather than skill driven is adopted, then "early delays are magnified at each additional step as the gap increases between what children bring to the curriculum and what the curriculum demands" (Whitehurst & Lonigan, 1998, p. 865).

Finally, a literacy curriculum or program should be *comprehensive*. Print-specific knowledge and skills for learning how to read and write and the knowledge, skills, and dispositions that support reading and writing for meaning should be addressed. Since standards reflect the expectation that students will be able to participate in a variety of literate communities, a comprehensive curriculum also includes multiple types of texts and topics. Culturally diverse literary texts, for example, provide opportunities for students to gain insights into human values. Similarly, a variety of informational texts provides opportunities for students to gain familiarity with different vocabulary, text structures, and ways of thinking in different areas of study (Lloyd-Jones & Lunsford, 1989).

Research literature frequently distinguishes between "foundational" and "advanced" knowledge and skills. The term "foundational" is often used to denote a focus on print-specific knowledge and skills, such as the alphabetic principle (see, e.g., Good, Simmons, & Kame'enui, 2001). "Advanced" refers to knowledge and skills customarily associated with reading and writing for meaning, such as the ability to summarize. A standards-based curriculum should include foundational knowledge and skills but not mandate that they be taught before more advanced knowledge and skills. The specific content covered by a comprehensive literacy curriculum is discussed in more detail in the sections that follow.

Foundational Knowledge and Skills

Just as the standards-based mathematics curriculum should cover foundational concepts such as number systems, geometry, and probability, as well as problem-solving and computational skills, a standard-based literacy curriculum should include a number of core concepts and skills:

- Phonemic awareness – the idea that words have sounds as well as meaning
- The alphabetic principle – referred to by some curriculum developers as the "logic of the print-sound code"
- Voice-print match, punctuation, and other print-related concepts
- Phonics – patterns of letter[s]-sound correspondences
- Word identification, sight vocabulary, and spelling
- Strategies for determining and expressing meaning (e.g., looking for semantic or syntactic cues; using basic grammar)
- Handwriting and keyboarding

Although a standards-based curriculum covers these foundational concepts and skills in the primary grades, this does not mean that all children need to be exposed to this content to the same extent. Many children enter kindergarten knowing all of the letters of the alphabet and their corresponding sounds. These same children often enter first grade already reading. Other children have very little letter and sound knowledge even when they enter first grade.

In addition to foundational knowledge and skills, learning to read and write requires a positive attitude toward and interest in reading and writing. Personal motivation and literacy habits are addressed in standards documents. For example, *Standards for the English Language Arts* (NCTE/IRA, 1996) states that "students use spoken, written, and visual language to accomplish their own purposes" (p. 3); the New Standards Primary Literacy Committee (1999) notes that "reading a lot" and "writing daily" are expectations for second-grade students (pp. 154,160). Literacy curricula aligned with these standards should provide a range of texts, topics, and genres that offer choices and capture students' interests.

Advanced Knowledge and Skills

Research as well as national-level standards documents suggest four common strands of knowledge and skills that support reading and writing for meaning:

- Fluency
- Vocabulary
- Comprehension and metacognitive strategies
- Composition and advanced grammar

Traditionally, fluency has been considered to result from a combination of speed and accuracy in recognizing words. More recently, however, this conception of fluency has been expanded. In 2000, the National Reading Panel published its report *Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction*, which reviewed the results of the panel's meta-analyses of reading research. Fluency, the panel noted, has come to be understood as also including speed and accuracy in grouping words appropriately, the rapid use of punctuation, and "a determination of where to place emphasis or where to pause to make sense of a text" (p. 3-6). The reader must carry out all of these processes quickly and typically without conscious attention. Fluency, then, is both the bottleneck and gateway to reading for understanding; it frees and supports mental capacity for strategic processing of content and for creating meaningful interpretations (Perfetti & Roth, 1977). Difficulty decoding, recognizing words, or making sense of a passage all disrupt fluency. On the other hand, ease of decoding, word recognition, and sense making all contribute to fluent reading.

It is commonly accepted that fluency develops with practice – a notion seemingly supported by the 2000 National Assessment of Educational Progress fourth-grade reading data, published in *The Nation's Report Card: Fourth-Grade Reading 2000* (Donahue, Finnegan, Lutkus, Allen, & Campbell, 2000). Students who reported reading more pages daily in school and for homework had higher average scores than students who reported reading fewer pages daily. Researchers and literacy experts (e.g., Chall, 1996; Ehri, 1994) tell us that frequent, successful practice in reading text helps beginning readers to consolidate and confirm their knowledge of the print-sound code; it also builds their confidence around a sight vocabulary – high-frequency words that they recognize rapidly.

A reading curriculum built on a series of books of increasing difficulty can provide students with opportunities to develop their fluency. At the appropriate level of difficulty, students can read and reread text orally, which helps them gain the familiarity they need to automatically recognize words and group words appropriately, and then move through increasingly difficult levels of text. Because basal series serve these purposes for average students at each grade level, they satisfy the needs of many students and teachers. Supplemental reading materials, however, are needed to help students who read substantially above and below grade level develop fluency.

Vocabulary is a cornerstone of literacy development. As an indicator of the extent and quality of students' knowledge of virtually any subject matter, performance on vocabulary tests is both predictive of and a consequence of good reading (Alexander & Jetton, 2000; RAND Reading Study Group, 2000).

Vocabulary development is critical to success in every subject area; therefore, it is a responsibility shared by many teachers, not just English language arts teachers. There are a number of ways to help students expand their vocabulary, which are discussed in more detail in the section about tailoring instruction to meet students' learning needs (see pp. 16-18). One approach that has curricular implications is *wide reading* (Marzano, Seger, LaRock, & Barton, 2000) – that is, reading many books from a variety of genres, about a variety of topics, and at increasing levels of difficulty. It is estimated that children can learn 750 to 1,500 new vocabulary words a year from incidental exposure during wide reading. In order to support students in reading widely, schools and districts should ensure that students have access to a range of reading materials.

Reading comprehension, or reading with understanding, consists of both superficial memory of text as well as deep understanding of the subject matter. According to Kintsch (1998), deeper understanding of text is learning from text. As Chall (1996) notes, students should "learn the new" – new knowledge, information, thoughts, and experiences (p. 20). These are high expectations. Students should be able to connect new information with prior knowledge so that this knowledge becomes integrated and supports their understanding and judgment in new situations. Thus, the range of comprehension questions and practice exercises in a standards-based curriculum must entail recall and higher order responses *and* applications to both immediate and future situations.

The fourth strand of advanced knowledge and skills that support reading and writing for meaning encompasses composition and advanced grammar. Much could be written about this set of competencies, but in short, learning to write well involves developing many interrelated lower order and higher order skills and knowledge. It also involves learning the intellectual/creative processes and habits of composing and communicating a meaningful set of ideas. Extensive writing experience is widely assumed to be essential for the development of high levels of writing competence (Hayes, 2000). Thus, writing curricula ought to be well articulated across grades so that students have opportunities to build on and consolidate their prior learning and experiences and reach high standards.

THE IMPORTANCE OF TEACHERS' KNOWLEDGE

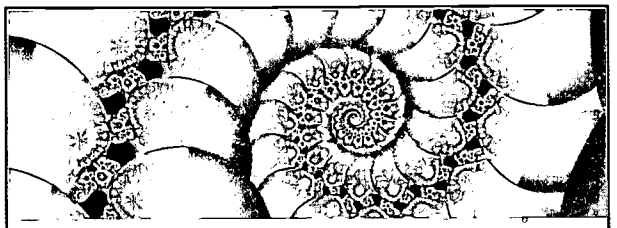
A curriculum that is comprehensive, developmentally sequenced, and aligned with standards and benchmarks is only as good as the teachers who use it. Recent research on exemplary literacy teachers indicates that teachers' knowledge is a critical link in helping all students become literate. Exemplary teachers, whose students achieve at high levels, understand their subject matter – literacy, literature, and language. They also understand the developmental stages of becoming literate. With this pedagogical content knowledge, they are able to appropriately select, reinforce, and expand the curriculum in response to what students need to become better readers and writers.

> ***"Teachers' knowledge is a critical link in helping all students become literate."***

Exemplary literacy teachers exhibit thorough, deep, and accurate knowledge of language. They tend to be, in their own words, masters of language – kings and queens of phonics, word pronunciation, and spelling or kings and queens of grammar and literature. They have a broad knowledge of literature from a diversity of cultures and genres, and books written at different levels of difficulty (Langer, 1999).

Exemplary teachers apply their knowledge every day in their classroom practices. Stahl (1998) explains that effective early literacy teachers carry in their heads a scope and sequence of phonics skills, along with knowledge of where every child is in relationship to that scope and sequence. They are able to target instruction to a child's developmental level rather than blindly follow the instructional sequence laid out in a guidebook. Langer (1999) highlights an exemplary middle school teacher who called herself the "Grammar Queen" who was masterful at using "literature the students read as models for targeting conventions, language choices, literary concepts, and stylistic devices" (p. 17). She was able to do this without interfering with students' efforts to interpret meaning by using a conversational style that included comments, direct statements, and reminders of how concepts and their applications connect across lessons. Furthermore, exemplary literacy teachers represent the core ideas of what it means to be literate using "routine demonstrations of how literate people think as they read and write – including errors and self-corrections" (Allington & Johnston, 2000, p. 15).

Exemplary teachers distinguish developmentally different ways of reading and writing descriptively and functionally. Kindergarten and first-grade teachers, for example, show their students by their actions, modeling, and feedback that there are



Effective Classroom Practices for Literacy

- Emphasize application, not just acquisition
- Are tailored to students' learning needs
- Are process oriented
- Use reflective and substantive conversations
- Use assessment to guide early intervention

different ways to read and spell, each of which serves a different learning purpose or is appropriate for a different stage of early literacy. There is "pretend reading," "finger-point reading," and "real reading"; there is both "sounding out" and "word identification by analogy." Likewise, exemplary primary grade teachers understand the different types and purposes of spelling. For example, they know that "sound-spelling," or "invented spelling," reinforces knowledge of letter-sound relationships, whereas conventional spelling of phonetically irregular words is critical for successful communication.

Exemplary teachers recognize which students are likely to benefit from more practice with a particular approach to reading or writing and which students are ready to move on. They also know when to let students discover different concepts or strategies themselves and when to explicitly teach a particular concept or strategy (Allington & Johnston, 2000; Cunningham, 2000).

Because they know their subject matter and literacy development so well, exemplary teachers practice conceptual selectivity (Pressley et al., 2001) – that is, they are selective about the strategies and materials they use in their classrooms and typically don't have an allegiance to any one philosophy (e.g., whole language). In a recent survey (Heistad, 1997), exemplary second-grade teachers tended to disagree with the idea that reading and writing develop naturally like speaking. This finding suggests that they acknowledged responsibility as teachers for creating opportunities that foster reading and writing development. They supplement basal textbooks with phonics worksheets and use phonetically controlled reading books and trade books to meet students' learning needs (Heistad, 1997). Students of exemplary teachers attain significantly higher levels of reading comprehension compared to other students.

Exemplary literacy teachers' knowledge of language often extends beyond English. They encourage and expect biliteracy in their classrooms. These teachers know which print-sound code concepts from a student's first language readily transfer to English and which can interfere. For example, when Spanish-literate students learn to read English, their prior knowledge about consonants can be activated and built on because the letter-sound associations for consonants are similar enough in both English and Spanish. On the other hand, because vowel letters look the same in Spanish and English but represent very different sounds, teachers are careful to point out the differences to avoid confusion (Peregoy & Boyle, 2000).

Exemplary teachers also understand the benefits of making varied reading materials written in both English and a second language available to students. They also know how to organize their classrooms and interact with students in a way that encourages students to use both languages for academic purposes. For example, in a third-grade bilingual classroom studied by Moll, Sáez, and Dworin (2001), students used the variety of resources available to them in English and Spanish to research a particular theme or topic. One of the bilingual students highlighted by Moll and his colleagues read in one language and wrote about what she had read in the other language. "Through such routines or practices," Moll et al. wrote, "children learned to use their

bilingualism deliberately, consciously, to access and manipulate resources for intellectual and academic purposes" (p. 444).

Exemplary literacy teachers understand and are interested in students' diverse cultures and backgrounds. They believe that each student's language and community background are unique strengths to be built upon. Knapp, Adelman, et al. (1995) found that exemplary teachers in large, urban, elementary schools, for example, focused primarily on the meaning expressed in students' writing, rather than on specific language mechanics. They also designed instruction so that students could bring their personal experiences to the classroom and didn't shy away from sensitive or uncomfortable issues that sometimes arose as a result.

It's important to note that most beginning teachers haven't had the experiences or learning opportunities they need to develop the pedagogical content knowledge that is characteristic of exemplary teachers. Developing this knowledge is a process that occurs over time as teachers gain more experience and engage in professional development activities, such as mentoring and other peer collaborations. In the early years of teaching, novice teachers typically need more support, either through more structured curriculum materials and/or mentoring support (Stahl, 1998). Schools and districts can further teachers' development by providing such materials and professional development experiences.

EFFECTIVE CLASSROOM PRACTICES FOR LITERACY

This section highlights five categories of classroom practices that teachers can use to help their students become proficient readers and writers. Examples also have been included that illustrate how teachers might use these practices in the classroom.

Balance Application and Acquisition

Effective classroom practices are those that emphasize the application, not just the acquisition, of print-sound code knowledge. Acquiring knowledge is an important aspect of becoming literate, but applying knowledge is critical. As students apply their emerging knowledge, they confirm and refine it, see its value, and become more familiar with it so they can access this knowledge more quickly in the future.

Practices for teaching letter-sound correspondences have traditionally emphasized acquisition. Students have frequently been taught letter-sound correspondences in isolation (e.g., *a* says /a/ as in "cat," *b* says /b/ as in "bat," and so on). Mastering recall of these individual elements of the print-sound code became a significant benchmark goal that consumed teachers' and students' attention. Little attention was paid to learning to read and write with and for meaning.

Whole language advocates have criticized these practices, arguing that children learn to read and write naturally, much like they develop spoken language, without much attention to mastering isolated phonics elements. From the whole language perspective, children learn to read and write as a result of self-directed inquiry and immersion in a responsive community of language users.

Developing language naturally is facilitated by applying knowledge but also by coaching and prompting from adults or more knowledgeable peers. Chall's (1996) description of children progressing from pretend reading to reading by letter cues supports the language development view of learning how to read: "[Novel printed words] and letter-sounds

The Language Experience Approach

Below is an illustration of a child's written plan for "playing farm."

Ryan's message says, "I am going to feed the chicken." He attempted to write the first three words (*I* for *I*, *M* for *am* and *G* for *going*) and dictated the rest of the message to the teacher, so the message combines Ryan's writing and his teacher's writing.

Ryan's writing shows his emerging knowledge of the print-sound code and its application to writing his plan down on paper. His writing suggests that he knows the correspondences between the letter *M* and the /m/ sound and between the letter *G* and the /g/ sound. As he reads his message back and learns to match his writing to his voice, his knowledge about these elements will be confirmed and strengthened.

Note: Adapted from *Vygotskian Approach to Play: How Can We Assess Play and How Can We Implement Play in Preschool and Kindergarten Classrooms to Promote Self-Regulation and Literacy?*, presentation by E. Bodrova, D. J. Leong, R. Hensen, and C. Hughes, 2000. Used with permission.

have to be learned from those who know them – teachers, parents, siblings, classmates. There is much asking and telling, practicing 'orally' and being confirmed" (p. 44). Adults, siblings and classmates answer inquiries and model how to use letter-sound knowledge to identify and spell words. The emphasis is on the application, not just the acquisition of letter-sound relationships.

In preschool and kindergarten classrooms, practices that emphasize the application, not just the acquisition, of letter-sound knowledge give children the strong foundational experiences they need to become good readers and writers. For example, practices that encourage and support children's early attempts at writing messages result in early literacy gains. This early writing helps children explore and learn how letters and sounds correspond. When young children write, and then read their writing, they continually discover, learn, and apply new information about the print-sound code. As Bodrova, Leong, Paynter, and Hughes (2001) explain in *Scaffolding Literacy Development in the Kindergarten Classroom*, "Children who start experimenting with writing in their preschool years and write a great deal in kindergarten tend to become good readers regardless of the type of reading program their teachers use" (p. 60).

The Language Experience Approach is one approach that successfully encourages young children to engage in early writing attempts. This approach involves teachers capturing talk in writing – what Snow et al. (1998) describe as "writing down what children say and then leading them to appreciate that what has been written is what they have said" (p. 183). Capturing talk in writing gives children and teachers a shared, spoken-written experience to examine. Effective teachers watch and listen to children and ask guiding questions to make sure that students learn core concepts and skills in the process of examining the "talk in writing." Both direct instruction and discovery learning are used in the language experience approach. Some children will discover the alphabetic principle, for example, but the teacher may also point out particular concepts or phonics elements exemplified in children's writing. This approach can be used to help students think ahead about an event and plan what they will do. (See sidebar.)

Evidence of effective classroom practices in kindergarten and beyond indicates that children benefit from systematic phonics instruction, which "typically involves explicitly teaching students a prespecified set of letter-sound relations and having students read text that provides practice using these relations to decode words" (NRP, 2000, p. 2-92). For example, a study conducted by the National Reading Panel (2000) compared the effects on children's reading and spelling of systematic, planned phonics instruction and unsystematic or no phonics instruction.

Systematic phonics instruction, the panel notes, stresses students' acquisition of letter-sound correspondences but also students' use of these correspondences to read and spell words. The panel found that systematic phonics instruction contributed more to children's growth in reading than programs providing unsystematic or no phonics instruction. The panel also found that systematic phonics instruction significantly affected reading comprehension for kindergarten and first-grade students. These findings, the panel commented, should "dispel any belief that teaching phonics interferes with children's ability to read and comprehend text; quite the opposite is the case" (p. 2-113).

Among the systematic phonics approaches studied were three modifications of the Reading Recovery© format developed by Clay (1993). The common components of the modified Reading Recovery© programs illustrate the programs' emphasis on the acquisition and application of phonics:

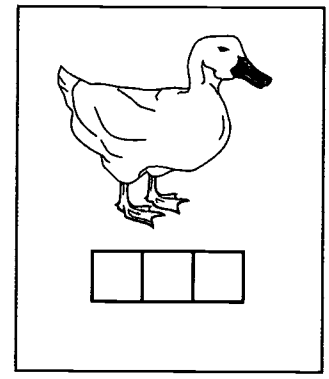
1. Manipulatives are used to engage children in the study of words. For example, prior to learning how to use letters to represent each sound in a word, children use small objects such as pennies, chips, or counters to "record" sounds in Elkonin boxes, thus learning to break a spoken word into its component sounds. (See sidebar.)
2. Teachers engage in metacognitive coaching. While students are reading, teachers prompt them to use strategies to solve word identification problems.
3. The majority of lesson time is used to put phonics to use in reading books and writing sentences.

In grades one through three, research on schools serving student populations with high academic needs also supports the use of practices that emphasize application, not just acquisition, of phonics. A study by Taylor, Pearson, Clark, and Walpole (2000), for example, found that teachers of students who made significant gains in beginning reading frequently provided coaching and engaged students in metacognitive dialogues to help them solve word-identification problems. The coaching reinforced students' attempts at sounding-out words on the basis of their knowledge of phonics and encouraged persistence and flexibility with a variety of strategies to identify printed words. A first- or second-grade teacher-student metacognitive dialogue might go something like this:

> What if you come to a big long word? Yes, sound it out. What else can you do? Yes, you can twist it a little (e.g., try a different vowel in "terrible"). Also you can ask yourself if it makes sense. And if you try these things [and still don't know the word], then what do you do? Yes, skip it, or what else? Yes, you can ask someone. (Taylor et al., 2000, p. 136)

Using Elkonin Boxes

The picture below illustrates the use of Elkonin boxes to study the sound composition of a word. The child is shown a picture of a familiar object and is asked to name the object (e.g., "duck").



Then the child is asked to say the same word, articulating all of its sounds separately starting with the first: /d/-/u/-/k/. As the child pronounces each sound, he or she pushes a plastic chip or small object into the corresponding box underneath the picture. Note that the number of boxes matches the number of sounds (in this case, three) and not the number of letters in the word.

Note: For more information on using Elkonin boxes, see *Scaffolding Literacy Development in the Kindergarten Classroom*, Bodrova, Leong, Paynter, and Hughes, 2001.

Moreover, this same study and others (e.g., Education Trust, 1999) found that in high-performing, high-needs schools, first-, second-, and third-grade students spent substantial amounts of time most days simply reading. In these high-performing schools, students spent an average of 28 minutes per day in independent reading – 10 more minutes per day than was spent in independent reading in schools where students were not developing foundational skills and reaching grade-level literacy standards and benchmarks (Education Trust, 1999; Taylor et al., 2000). The high rates of beginning reading success in these schools are attributable, in part, to ample opportunity to confirm, refine, and extend emerging print-sound code knowledge by reading stories and informational texts.

Tailoring Instruction

Students have different learning styles and academic needs and reach developmental levels at different times. Effective teachers understand these differences and use assessment information, conversations with students, and other sources of feedback to tailor instruction to meet individual students' evolving learning needs. There are many ways that teachers can effectively modify instruction in the classroom.

Grouping students in different ways is one way that teachers can tailor instruction. Grouping structures can vary in a number of ways and teachers can make decisions that are responsive to students' needs. For example, research by Heistad (1997) found that effective teachers used whole-class instruction some days to address common learning needs and small-group instruction other days to differentiate instruction according to developmental needs. Exemplary elementary schools in Texas grouped students for reading instruction by ability across different grades (Briggs & Thomas, 1997). The principal of this school, reported, however, that student grouping was not a stagnant process – students were individually evaluated and then placed in groups, but moved to higher groups as soon as they were ready. Still another study found that the most effective teachers reported using whole-class instruction less frequently than the least effective teachers. The more effective teachers said that small-group instruction and the focus of that instruction were among the most important factors for helping struggling readers (Taylor et al., 2000).

By grouping students, teachers can differentiate instruction and experiences so that individual students learn and practice what they need to become more independent readers. This kind of approach is illustrated by one exemplary teacher's description of her second-grade classroom:

> I meet with seven independent readers for brief periods of time to set up independent lessons. . . . A group of seven other students are non-readers. I meet with them to do specific lessons every day using guided reading practice. This group has made progress. Two have moved up to another group. One special education student has been absent a lot. The other four will need continued special help through the year. (Heistad, 1997, p. 15)

In addition to grouping structures that meet students' academic needs at different developmental stages, grouping arrangements also can be used to bring together students with common interests and/or complementary talents. Other effective grouping practices include joint projects, which can capitalize on students' individual interests or areas of expertise in language arts but also in other areas (e.g., visual and performing arts).

Early interventions are another form of tailoring instruction to meet students' learning needs. Young children who do not appear to be developing phonemic awareness and appreciation of the alphabetic principle need early interventions to help them develop these skills and understandings. Otherwise, they may have difficulty reading and writing throughout elementary school (Ehri & McCormick, 1998; Juel, 1988).

Early interventions that effectively help children develop an appreciation of the alphabetic principle rely on a pre-selected subset of print-sound code elements for children to study (National Reading Panel, 2000). Not all 26 letters or all of the

44 phonemes of English need to be introduced. Literacy researcher Marilyn Jager Adams and her colleagues (Adams, Foorman, Lundberg, & Beeler, 1998) suggest starting with a small subset of consonants (*s, m, d, p, t, n, g, b, r, f*) and the short vowels (*a, o, i, u, e*) to help children come to appreciate the alphabetic principle. These consonants and vowels can easily be combined and manipulated to make and break words, to demonstrate the logic of the print-sound code, and to highlight the sound, in addition to the meaning, of words. Later, when they are helping children develop understanding of phonics and its applications, teachers can introduce other letters and letter patterns, and their corresponding sounds. As Adams et al. point out:

> Building students' ability to work confidently and reflectively with a few letters is far more valuable than rushing to cover some larger number of letters. When children have grasped the nature of the system, the introduction of new letters will proceed with far greater ease and speed. (p. 93)

Research indicates that effective early interventions in kindergarten and first grade usually are delivered in brief (approximately 30-minute) tutoring or small-group sessions. They typically include activities and direct instruction aimed at addressing individual needs, in one or more of the following foundational skills: phonemic awareness, appreciation of the alphabetic principle, use of phonics and other sources of knowledge to identify printed words, and sight vocabulary (Hiebert, Pearson, Taylor, Richardson, & Paris, 1998; Vellutino et al., 1996).

Research also indicates, however, that effective primary grade interventions focusing on foundational skill development do not have a 100 percent success rate. Generally, these interventions have a failure rate of four to six percent (Torgesen, 2000; Vellutino et al., 1996). Thus, even with intervention, not all primary grade students reach grade-level benchmarks in literacy. As noted by Torgesen (2000), although school programs successfully help most students learn how to read at grade level by the end of third grade, it is still not clear how to assist children with the most serious disabilities in acquiring adequate word-level reading skills in the early elementary grades. The implications of these findings are that these students need exposure to information and text through alternate modes of presentation (e.g., oral language, video) to ensure that they have the opportunities to learn the knowledge and skills needed to meet standards associated with reading and writing for meaning and understanding. As Juel (1988) notes:

> Every effort must be made both to keep them [poor readers] motivated to read and to keep up their listening comprehension so they do not fall so far behind in vocabulary, concepts, and so on. The age-old technique of reading to children often seems to fit the requirement nicely and should not be forgotten in the elementary grades. (p. 448)

Vocabulary is centrally important to becoming literate, and thus should not be neglected as a goal of teaching and learning. Different students, however, develop vocabulary in different ways. Many students learn new terms and phrases incidentally as they read a variety of materials. Others who struggle to read typically do not develop a great deal of vocabulary from incidental exposure through reading. These students benefit from more systematic selection and targeting of vocabulary as well as from direct instruction in vocabulary learning strategies.

Resources: Teaching Vocabulary Across Content Areas

Teaching Reading in the Content Areas: If Not Me, then Who? (2nd Ed.), Billmeyer and Barton, 1998

Teaching Reading in Science: A Supplement to Teaching Reading in the Content Areas, Barton and Heidema, 2001

Teaching Reading in Mathematics: A Supplement to Teaching Reading in the Content Areas, Barton and Heidema, 2000

Essential Knowledge: The Debate over What American Students Should Know, Marzano and Kendall, with Gaddy, 1999

To capitalize on wide reading experience for vocabulary development, Marzano et al. (2000) recommend that students use the following strategies:

1. Keep track of new words in a vocabulary notebook that organizes entries by meaningful categories (e.g., occupation, feelings/emotions, machines/tools).
2. Learn words on high-frequency word lists.
3. Use a selected new word at least three times a week in writing or conversation.

For students who struggle to read, pre-selected lists of key vocabulary terms and phrases are important for focusing their attention and efforts on knowledge that brings success. This identification of key terms and phrases is often the joint responsibility of content-area teachers and reading or language arts teachers. Once key terms have been identified, learning strategies and time should be used to study them. One vocabulary strategy to teach students involves five steps related to the acronym TOAST (i.e., test, organize, anchor, say, test) (NRP, 2000).

Another strategy involves analyzing words in a particular category by distinguishing features (e.g., the distinguishing features of various types of rocks) (Blachowicz & Fisher, 2000).

In order to appropriately tailor instruction to help students reach standards and benchmarks in fluency and reading comprehension, teachers need a repertoire of strategies to draw on. Just as kindergartners and first graders need opportunities to practice different types of reading (e.g., "sounding-out" and "word identification by analogy"), students in later grades need different types of reading practice for different types of skill development or because the difficulty of a text or task requires a different approach. For example, research indicates that repeated oral reading practice is effective for improving reading fluency, whereas silent reading accompanied by related substantive discussion is effective for improving reading comprehension (NRP, 2000).

Teaching Processes

Process-oriented instruction is particularly effective for helping students develop abilities that are critical to reading and writing for meaning and understanding. Process-oriented practices teach students "how-to" skills – such as activating and reflecting on their prior knowledge, reading strategically, writing to learn, and using self-regulating habits.

Process-oriented instruction is consistent with the characteristics of good readers. Research by Pressley (1998) suggests that good readers are strategic readers. Research has shown that students can be taught to apply process-oriented strategies and other strategies to improve their reading comprehension abilities. The National Reading Panel (2000), for example, identified a number of reading comprehension strategies that "appear to be effective and most promising for classroom instruction" (p. 4-5): comprehension monitoring, cooperative learning, graphic and semantic organizers, story structure, question answering, question generating, and summarizing. One of the panel's most significant findings was that these strategies are effective as

stand-alone strategies, but have significant effects when combined, leading the panel to comment: "Taken together, the evidence supports the use of combinations of reading strategies in natural learning situations" (p. 4-46).

One of the most studied multiple strategy approaches to developing comprehension is reciprocal teaching, developed by Palincsar and Brown in the early 1980s (see, e.g., 1984). A meta-analysis by Rosenshine and Meister (1994) of the effects of reciprocal teaching showed that this strategy can significantly influence reading comprehension.

Reciprocal teaching involves a teacher first modeling a strategy and then explaining how to use it. Then students practice two or more of four strategies: generating questions, summarizing, clarifying word meanings or confusing text, and predicting what might happen in the next segment of the text. In small groups, students watch and practice the strategies on a passage of expository material, paragraph by paragraph, first with the teacher, then among themselves, providing instructional support for one another. The practice becomes a dialogue. For example, one student asks a question, another answers, and a third comments on the answer; one student summarizes and another comments on or helps improve the summary. (See sidebar.)

Reciprocal teaching can be used effectively at various grade levels when teachers adapt the approach to meet students' learning needs and preferences. In the early grades, for example, teachers can monitor and facilitate the process to a greater extent with texts that students read or hear. An early case study conducted by Brown and Palincsar (1989) found that the listening skills of first-grade students who needed more individualized attention greatly improved when teachers used an adaptation of the reciprocal teaching approach.

Using Reciprocal Teaching to Enhance Comprehension

After Mrs. Webster had modeled the process of reciprocal teaching, she asked several of her high school students to serve as student leaders for an upcoming project about poetry. As part of the unit, students read several passages about poetry. Susan, one of the student leaders, summarized the first passage:

"Poetry is a lot like music. There's a lot of variety in what is considered poetry, and rhythm is a key device for expressing ideas and feelings. There's not a black-and-white difference between poetry and regular prose. It's more like a continuum with distinct rhythm at one end and no discernable rhythm at the other."

Mike, another student, added, "Many poems have a rhythm or structure to the lines. One example is the four-line stanza where the second line rhymes with the fourth. There are different types of poetry — for example, lyric poetry, narrative poetry, and dramatic poetry."

Lydia, another student, then began the questioning phase by asking questions about specific information from the passage. After students answered the questions, Lydia asked the class if anyone had questions they wanted to ask to clarify confusing points in the passage.

Jake said he was confused about what the author of the passage said about poetry as art and "didactic" poetry. Brian answered, "There's a difference between poetry that's artistic and writing that's only technically considered to be poetry because it rhymes — for example, sayings that help people remember facts, like 'thirty days hath September, April, June, and November.' They're technically poetry, but not very poetic."

Finally, Lydia asked students to predict what they thought the next passage, entitled "How Poetry Has Changed Over the Centuries," might say. Nicole said that the passage would say that poetry has changed over time as people have changed the way they express their feelings and ideas, just like music has changed over time.

Note: Adapted from *What Works in Classroom Instruction* (pp. 38–39), by R. J. Marzano, B. B. Gaddy, and C. B. Dean, 2000, Aurora, CO: McREL.

Writing down summaries and analyses of the substance of what they read also can help students read to learn. Experienced teachers know that writing can deepen students' conceptual understanding. Essay writing, which provides students with opportunities to make connections and think broadly about a topic, has been found to be more beneficial than answering questions or taking notes regardless of students' prior knowledge (Armbruster, 2000).

In a review of research on learning strategies in middle school science, Swafford and Bryan (2000) report that when students write to explore their own ideas, share ideas with peers, and reflect on those ideas in teacher-led discussions, explanations of science concepts and phenomenon increase in complexity and students increase their use of evidence to support their theories. Learning logs, when used in conjunction with hands-on activities, can be used as a means for communicating learning to a teacher and for receiving feedback. As Swafford and Bryan note, "Writing not only helps students organize their observations, but also gives the teacher an opportunity to intervene and invite students to consider alternative evidence" (p. 156).

Process-oriented instruction for helping students meet high writing standards is also supported by research and experience. Hillocks (1995), a researcher and teacher, advocates the use of inquiry as a pre-writing strategy. Since a key to writing is learning how to recall content without prompts from peers, teachers, or other conversational partners, explicit teaching of inquiry strategies should be part of writing instruction. Basic strategies for inquiry include observing, questioning, constructing representations and interpretations, and testing hypotheses. In addition to inquiry, other strategies for recalling content include mapping, listing, brainstorming, analyzing data to develop claims for arguments, and paying close attention to sensory perceptions for generating detail. Hillocks recommends that students learn these strategies through a combination of direct instruction, modeling, and ample opportunity for both guided and independent practice.

Some state writing assessments encourage the use of process-oriented instruction. For example, in Kentucky, the state writing assessment in 1997–1998 included both an on-demand written response to a prompt as well as a portfolio of original, genre-varied compositions collected over one year. Teachers in rural and urban Kentucky studied by Wolf, Borko, Elliott, and McIver (2000) reported that as a result of the portfolio requirement, they dramatically changed their writing instruction to a workshop-oriented approach. Teachers used workshops to teach students the process of writing, show them that the purpose of writing is to make meaning, and to share their own fascination with writing. Children also listened to writers from their communities come speak in their classrooms. Students were taught how to reflect on their writing through both self- and peer-critiques, and to "fire-up" a piece to make it more readable and engaging.

Finally, Hillocks' (1984) analysis of different approaches to teaching writing tells us that students improve their writing when teachers (1) make explicit for them the criteria against which their writing will be judged, (2) allow and encourage them to work together using that criteria to judge writing, and (3) expect them to justify their reasoning to each other. Judging pieces of writing according to specific criteria and revising written work according to suggestions generated through use of the criteria is a common practice in standards-based classrooms. For example, a whole-group lesson on informational writing in fourth-grade standards-based classroom might progress as follows:

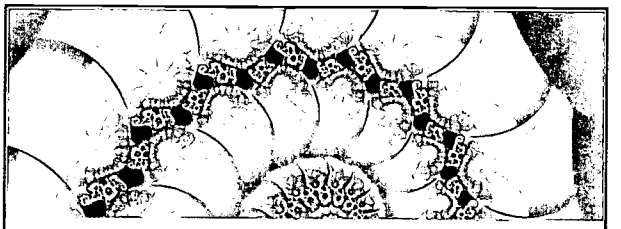
> Making transparencies of successful papers and using an overhead projector, I point out each of the criterion called for in the . . . rubric. Then I use my students' papers that have places where these criterion [*sic*] have not been met and have the students "revise" them by adding the missing elements. By using the overhead for this whole class activity, I ensure that each student recognizes all the elements that are part of the standard for the genre under discussion. After several of these sessions, most students are ready for the more complicated assignments that will follow. (Hampton, 2000, p. 14)

Meaningful Conversations

Reflective and substantive conversations among students and between teacher and students are characteristic of classrooms where high standards in literacy are expected and achieved. Reflective conversations are conversations that involve students in labeling and discussing patterns and principles of the print-sound code and other language conventions. Substantive conversations are conversations that involve students and teachers discussing the meaning of topics, arguments, and events in what they are reading and writing.

Word study is one approach to engaging students in conversations about language. Word study is instruction that includes activities for exploring and discussing patterns and principles of spelling and word meaning. According to Stahl, Duffy-Hester, and Dougherty Stahl (1998), in word study, "students examine words and word patterns through strategies such as sorting, in which students categorize words and pictures according to their common orthographic features" (p. 346). As students categorize words, they explain and discuss their reasoning with peers. By listening to each other's reasons for their choices, they consider alternative categorizations and reject or accept them to solidify their own understanding of the way words and the orthography work.

For example, when sorting certain sets of multi-syllabic words ending in /shun/, students can be guided to discover and discuss possible spelling-meaning connections. Consider, for example, sorting the following set of words under the lead words *definition* and *magician*: *composition*, *musician*, *physician*, *politician*, *competition*, *illustration*, *electrician*, and *explanation*. When students are asked to explain what the words in a category have in common, they may discover and explain the relationship between *-ion* and its role marking the noun form of a related verb (e.g., *composition* [compose]; *illustration* [illustrate]; *competition* [compete]) and between *-ian* and a label for a person engaged in related activity (e.g., *musician*, *electrician*, and *physician*) (Zutell, 1996).



Word Study: Teacher Resources for Elementary and Intermediate Grades

Words Their Way: Word Study for Phonics, Vocabulary, and Spelling Instruction, by Bear, Invernizzi, Templeton, and Johnston, 1996

Making Words: Multilevel, Hands-on, Developmentally Appropriate Spelling and Phonics Activities, by Cunningham and Hall, 1994

Making Big Words: Multilevel, Hands-on, Developmentally Appropriate Spelling and Phonics Activities, by Cunningham and Hall, 1994

"Nonability-Grouped, Multilevel Instruction: Eight Years Later," by Cunningham, Hall, and Defee, 1998

Calfee's Project READ, as described in "Phonics and Phonemes: Learning to Decode in a Literature-Based Program," by Calfee, 1998

"Using What You Know to Figure Out What You Don't Know: An Analogy Approach to Decoding," by Gaskins, Gaskins, and Gaskins, 1992

"The Directed Spelling Thinking Activity (DSTA): Providing an Effective Balance in Word Study Instruction," by Zutell, 1996

Word study activities are based on the assumption that learning orthographic knowledge involves more than rote memorization. Learning to use the print-sound code "includes a strong conceptual component. Students not only learn individual words, but acquire progressively more complex ideas about how words work" (Zutell, 1996, p. 99). Word study activities have been used to help students develop phonics knowledge, vocabulary, spelling and word recognition abilities. They stimulate reflective conversations about the way orthography works and help students

deepen their understanding of language concepts. Teacher resources for word study are presented in the sidebar on the previous page. All of the resources listed have evidence supporting their effectiveness for improving student reading and/or spelling.

In classrooms that encourage substantive conversations, there is a great deal of discussion about the meaning of what was read, not just about facts. For example, in one high school exemplary literacy program, a teacher asked students to begin a character analysis by posing critical questions (Langer, 1999). Students then selected two characters and compared the characters' viewpoints about the question, rather than listing character traits. Effective cooperative learning strategies also are critical to the successful use of substantive conversations. These strategies include teaching students the different roles they take on in their literary discussions: discussion director, literary illuminator, vocabulary enricher, summarizer, and connector (Langer, 1999). Teachers have students engage in "mind-to-mind discussions" with the expectation that they will "not merely work together, but sharpen their understandings with, against, and from each other" (Langer, pp. 37, 35).

Engaging students in thoughtful, literate conversations and classroom communities is one of Allington's (2001) recommendations for research-based literacy programs for struggling readers. He recommends that students and teachers engage in conversations about books and other materials that have the characteristics of out-of-school conversations. In out-of-school conversations about newspaper articles, novels, and other reading materials, participants make connections from text to self, from text to world, and from text to text. In addition, literacy circles or discussion groups, called book clubs, are used to replace traditional classroom talk patterns dominated by teacher control with classroom talk comprised of a balance of teacher- and student-initiated exchanges (Raphael, 1998; Snow-Renner & Apthorp, 2000).

In classrooms that encourage substantive conversations, teachers provide time for students to develop interests and explore ideas and themes in depth. They use think-alouds to model comprehension monitoring, summarizing, conversations with self, and a "willingness to pursue understanding" (Alexander & Jetton, 2000, p. 301). Teachers who facilitate, lead, and model self-correction, rather than attempt to be an authority on every topic, are more likely to encourage students to be independent, literate thinkers (Allington & Johnston, 2000). Such outcomes are directly aligned with the kinds of literacy habits and dispositions identified in national-level standards documents.

Discussions, writing conferences, and conversations about the substance and use of language in writing help students develop writing competence. In particular, talk that is conversational and includes explicit statements that point out conventions of language use are effective in helping students learn to write better. The *NAEP 1998 Writing Report Card for the Nation and the States* (Greenwald, Persky, Campbell, & Mazzeo, 1999) reports that students whose teachers frequently talked with them about their writing performed higher on the NAEP writing assessment.

Another key to helping students become good writers is to create opportunities for them to interact with their peers to solve writing problems and judge written work. Hillocks (1984) found that students who participated in student-led, small-group discussions that focused on solving problems outperformed students who participated in either teacher-led sessions or individual teacher-student sessions.

Prevention-Oriented Assessment

Prevention-oriented assessment is an essential tool for helping teachers and other educators know which students need additional instruction or early interventions. In early literacy, this type of assessment needs to be implemented in kindergarten through third grade and should align with standards and grade-level benchmarks for foundational skills and knowledge. This period of time is critical for helping young children develop the knowledge and skills upon which so much of later school success depends.

As the developers of one such system explain, prevention/intervention-oriented assessment systems are "designed to complement existing high-stakes assessment systems and preempt early reading difficulties from becoming established" (Good, Simmons, Kame'enui, 2001, p. 259). The goal is "to ruin the prediction" between earlier grade performance and later reading achievement (Good et al., 2001, p. 284). The assessments help identify students who need early intervention so that foundational skill development can be accelerated and students get help getting back on track. Such systems are designed on the basis of research about developmental trajectories that result in reading achievement at grade level at the end of third grade; their purpose is to help teachers help students get on and progress along such trajectories. Retention clearly is not a means for helping most students get back on these trajectories.

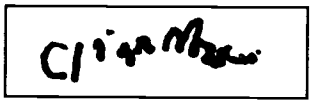
At each grade level, the assessments are aligned with particular benchmark goals for key foundational skills. In the winter of kindergarten, for example, students' phonemic awareness is assessed in terms of their ability to recognize similar initial sounds in words. In the spring of the same year, students' ability to segment words

The Early Literacy Advisor™

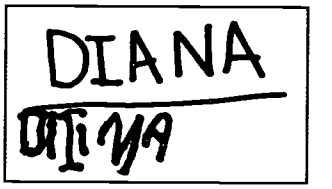
Using Assessment to Guide Instruction

One test in the Early Literacy Advisor™ is *Write Your Name*, a dynamic assessment of a child's ability to write his or her name. The task is administered at three levels, depending on the child's current level of performance. The assessment tracks the child's knowledge of letters, his or her ability to form the letters of the name, letter recognition, concepts of writing, the alphabetic principle, and penmanship characteristics. Two examples of children's writing collected during the test follow:

Four-year-old Diana cannot write her name correctly from memory.

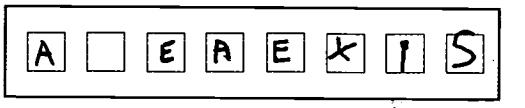


Yet, given a sample of her name written by her teacher, she can copy most of the letters correctly.



Another four-year-old, Alexis, can write her name correctly from memory.

However, when the teacher gives her a form with the first and third letters of her name already written, Alexis cannot fill out the missing letters.



Based on the results of the assessment, the ELA™ generates individual student profiles that include analyses of the error patterns and specific teaching suggestions geared to each child's current level of skill development. For example, Diana's profile would suggest activities for practicing letter formation and fine motor skills; Alexis's profile would include activities emphasizing the alphabetic principle and one-to-one correspondence. Suggestions are framed in terms of individual, small-group, or large-group activities so teachers can choose different venues to support the child's development.

Note: For more information, see *Scaffolding Literacy Development in the Preschool Classroom* (2nd ed.), Bodrova, Leong, Paynter, & Hensen, 2001.

phonemically is assessed. Kindergarten assessments also ought to include measures of letter identification, probes on early abilities to apply letter-sound knowledge to spelling, and other precursors to successfully learning how to read (e.g., voice-print matching and use of context to aid word identification). In first grade, assessments also ought to address word recognition, or sight vocabulary, both in and out of context. In second and third grade, measures of fluency and comprehension when reading grade-level texts may be appropriate for assessing progress toward third-grade benchmark goals.

> ***Prevention/intervention-oriented assessment systems are designed to preempt early reading difficulties from becoming established.***

Examples of prevention- and intervention-oriented assessment systems include the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) developed for the primary grades by Good, Simmons, and Kame'enui (2001), Phonological Awareness Literacy Screening (PALS), a system designed to provide teachers with a screening tool to help them determine which students would benefit from additional instruction (see PALS, n.d.), and the Early Literacy Advisor™ (Bodrova, Leong, Paynter, & Semenov, 1999). All three systems use Web-based data collection and reporting technology, but differ in the focus of the assessments at each grade level and the supplemental information provided.

Evidence supporting the utility of these assessment systems in kindergarten is emerging. Studies on these systems show that kindergarten students who are identified as needing additional instruction and are given interventions, significantly improve their foundational skills (Bodrova, Leong, & Semenov, 1997; Good et al., 2001). The interventions included instructional practices such as games and exercises aimed at developing phonemic awareness, and the use of language experience approaches to writing.

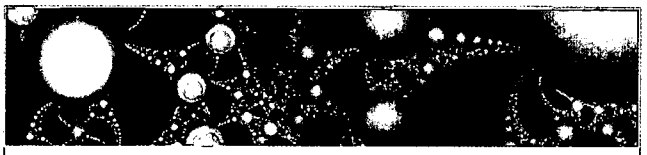
CONCLUSIONS

National standards documents in early literacy and English language arts clearly identify the knowledge, skills, dispositions, and habits expected of a literate graduate of the K–12 education system. These are high goals. Graduates are expected to be able to learn from reading, write to synthesize their thinking and communicate new knowledge, and participate in a variety of literate communities as reflective, critical, and creative thinkers. Grade-level benchmarks in kindergarten through third grade specify critical milestones that signal successful progress toward these high standards.

This chapter addresses some of the key classroom practices, instructional approaches, and interventions that effective teachers implement to ensure that their students become successful readers and writers. Teachers' knowledge of literacy, understanding of developmental stages in literacy, and appreciation of their students' diverse learning styles, academic needs, and backgrounds are critical to students becoming literate.

But teachers need supportive organizational structures and human and material resources in order to create learning experiences that result in success for all students. School and district leaders can provide valuable support to teachers in a number of ways. They can help provide the variety of resources teachers need to facilitate students' learning, such as basic and supplemental curriculum materials, time to collaborate, and flexible scheduling options that allow students to be grouped and regrouped depending on their instructional needs. As instructional leaders, they can provide pedagogical guidance in literacy, develop assessment systems that can be used to identify and monitor students' changing learning needs, and lead the process of data-based instructional decision making. Finally, and perhaps most important, they can help establish a culture focused around a shared belief that all students can meet high standards and a commitment to do what's needed to ensure that they do.

Chapter 3 BEYOND COMPUTATION: Teaching Mathematics



In This Chapter

- The importance of teaching for understanding
- The relationship between procedural fluency and conceptual understanding
- Characteristics of effective curricula
- The knowledge and skills teachers need to be effective
- Engaging students in learning through worthwhile tasks, hands-on experiences, and classroom discourse
- The use of calculators & computers in the classroom
- How assessment can be used to guide instruction

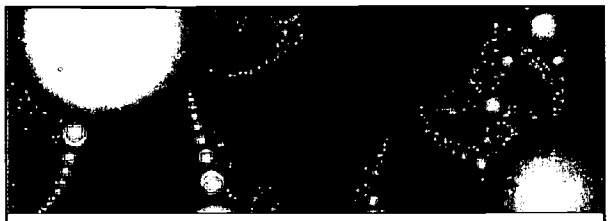
International, national, and state assessments indicate that U.S. students are not learning the mathematics they need to function in our high-tech economy and society. According to *Adding It Up: Helping Children Learn Mathematics*, a recent report of the Mathematics Learning Study Committee of the National Research Council (Kilpatrick, Swafford, & Findell, 2001), American students perform adequately on computational procedures, but they have limited understanding of mathematics concepts and have great difficulty applying mathematics to solve even simple problems. The primary reason that many U.S. students perform poorly is that they are not given appropriate opportunities to learn the mathematics knowledge and skills that will allow them to perform well.

Several reasons for the lack of such opportunities are possible: unclear or low expectations for learning, a mismatch between what students are expected to know and the knowledge that is taught, inadequate curriculum materials, and/or inadequate instructional approaches. This chapter touches on each of these, highlighting standards for mathematics learning and reviewing research-based characteristics of effective curricula and instructional practices – especially those that have been shown to help high-needs students reach high standards. Findings from recent research, translated into suggestions and guidelines for teachers and school leaders, also are discussed.

MATHEMATICS STANDARDS: SETTING THE BAR HIGH

Expectations for mathematics learning were formally described by the National Council of Teachers of Mathematics (NCTM) in its 1989 landmark document *Curriculum and Evaluation Standards for School Mathematics*. That document was revised and released in 2000 as *Principles and Standards for School Mathematics*.

Other groups, such as the American Association for the Advancement of Science's Project 2061 (1993) and the National Research Council's Mathematics Learning Study Group (Kilpatrick et al., 2001), have also clearly described the knowledge and skills that students should acquire in K–12 mathematics. In addition, statements about what students should know and be able to do in mathematics can be found in frameworks for national and international assessments, in particular, the *Mathematics Framework for the 1996 and 2000 National Assessment of Educational Progress* (NAEP, 1996) and *Curriculum Frameworks for Mathematics and Science: TIMSS Monograph No. 1* (Robitaille, Schmidt, Raizen, McKnight, Britton, & Nicol, 1993).



Clear and Specific Standards, as Judged by The American Federation of Teachers

Kansas — Fourth Grade

The student recognizes and performs up to two transformations (rotation/turn, reflection/flip, translation/slide) on simple two-dimensional shapes and uses cardinal or positional directions to describe translations such as move the triangle three units to the right and two units up.

Note: From *Kansas Curricular Standards for Mathematics* (p. 44), by the Kansas State Department of Education, 1999.

South Dakota — High School

The student will determine the domain, range, zeros, y-intercepts, end behavior, relative maximum and minimum points, and symmetry of functions.

Note: From *South Dakota Mathematics Standards Document*, (p. 36). Adopted 12/15/1998, by the South Dakota Department of Education and Cultural Affairs.

All of these documents describe high learning goals for students. They cover a range of mathematics content (i.e., numbers and operations, algebra, geometry, measurement, and data analysis and probability) and require students to learn key mathematics processes (e.g., problem solving, reasoning, representing and communicating mathematics ideas, and making connections). To meet these expectations, students need to be able to formulate problems in mathematics terms and adaptively use multiple representations, approaches, or even different arguments to support an idea, depending on their audience. Students also need to develop mathematics-specific listening and reading skills to understand and evaluate the communications of others.

Part of the motivation behind the development of the NCTM standards in 1989 was to raise expectations about mathematics learning from low-level, rote computation and routine use of formulas, to higher order understanding and application of concepts. In fact, understanding and learning to apply mathematics concepts in novel situations are the focus of most mathematics standards.

Teaching for understanding is a complex endeavor. It requires teachers themselves to have a deep understanding of mathematics concepts and know how to promote and assess students' understanding. For these reasons and possibly others, teachers spend more time teaching facts and concepts and having students practice the procedures needed to solve routine problems than they spend teaching reasoning, analytic abilities, and communication (Grouws & Smith, 2000; Stigler & Hiebert, 1999).

Helping students develop a deep understanding is worth the effort, however, as results from the 1996 NAEP assessment show. Students whose teachers emphasized higher order thinking skills and hands-on activities performed better overall on the 1996 NAEP assessment than students whose teachers did not emphasize these skills (Wenglinsky, 2000; Grouws & Smith, 2000). Similarly, Knapp, Adelman, et al.'s (1995) study of high-performing, high-poverty schools found that the most effective mathematics teachers focused on developing students' conceptual understanding. This focus helped to narrow achievement gaps, contradicting the notion that low-performing students are not ready or able to understand more advanced, complex material.

High standards for mathematics learning have been defined by professional groups at the national level. But standards defined by national groups have little influence on teachers. Particularly in this time of increasing accountability, teachers look to state standards to guide their curriculum, instruction, and assessment decisions. Unfortunately, the quality and content of state standards vary. Although some state standards are clear and specific (American Federation of Teachers [AFT], 1999) (see sidebar), some are vague; others omit challenging content. One way to improve the mathematics performance of students, then, is to examine state and local standards to

ensure that they promote the array and complexity of mathematics content and processes embodied in the NCTM and other national-level standards documents.

Having appropriate standards alone isn't enough, however. Students' opportunities to learn are limited if there is a mismatch between what they are expected to know and what is taught. The next section includes a discussion of the characteristics of curricula that provide students with the opportunities they need to improve their performance in mathematics.

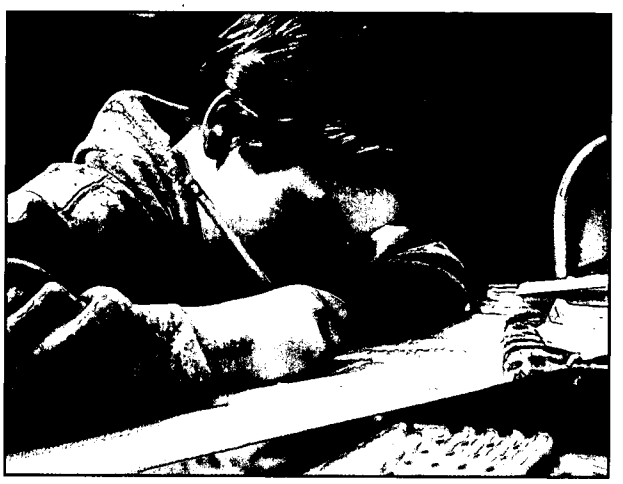
CHARACTERISTICS OF AN EFFECTIVE CURRICULUM

Students' learning of the body of knowledge defined by standards depends in part on the curriculum they experience. Research demonstrates that a curriculum that enables students to reach high mathematics standards has the following characteristics:

- Balanced – focuses on conceptual understanding and procedural fluency
- Comprehensive – includes all the important content strands of mathematics as well as computation and other procedural skills
- Aligned with state- and national-level standards, external assessments, and instruction
- Coordinated and coherent within and across grades – ideas are well developed and build on or connect with other ideas within and across grades

Balances Conceptual Understanding & Procedural Fluency

To many parents and community members, being good at mathematics means being able to perform basic computations such as adding, subtracting, multiplying, and dividing. As discussed earlier, many teachers spend considerably more time teaching such procedures than they do developing students' conceptual understanding or higher order processes such as problem solving and reasoning. Providing students with the opportunity to realize the vision of mathematics education described in standards requires a curriculum that balances procedural fluency and conceptual understanding.



As demonstrated by Knapp, Adelman, et al.'s (1995) study of classrooms in high-poverty schools, balancing procedural fluency and conceptual understanding is also important because it is more effective for developing students' mathematics skills and knowledge than simply learning discrete skills alone. In the Knapp et al. study, students of teachers who used a balanced curriculum that focused on developing students' conceptual understanding of mathematics as well as their procedural skills performed above average on state mathematics assessments. Further, research suggests that when teachers emphasize arithmetical procedures without also developing students' understanding of underlying concepts, students' development of more advanced mathematics knowledge and skills is handicapped (Carpenter & Lehrer, 1999; Hiebert & Carpenter, 1992).

The Relationship Between Conceptual Understanding and Procedural Fluency

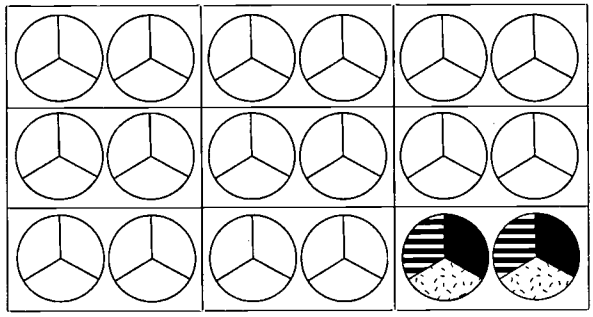
Mr. Doneleski asked his students to discuss with a partner what 18 divided by ⅔ means. After a few minutes, he asked for volunteers to share their discussion with the class.

Ariana said, "We said it means how many ⅔'s are in 18."

Kelly said, "Isn't that the same thing as ⅔ of 18?"

Ramon said, "No. Remember when we talked about things like 18 divided by 3. We said one way to think of that was how many 3's are in 18. This is the same thing."

To check students' conceptual understanding, Mr. Doneleski asked if someone would like to draw a picture on the board to represent 18 divided by ⅔. Taleka volunteered and drew the following.



Taleka went on to explain, "For each whole, there are 3 thirds, and two wholes have three two thirds. To find how many two thirds are in 18 wholes, just divide 18 by 2 — make pairs — and then multiply by 3. The answer is 27. 18 divided by ⅔ equals 27."

Carlos said, "Wait a minute, we went from division to multiplication. 18 divided by ⅔ equals 18 times ³/₂. Is that a rule? Does that always work?"

Mr. Doneleski asked his students to try some other similar examples and explain the algorithm in writing so they could see the connection between their conceptual understanding and the process. For homework students wrote in their journals about how understanding what division means helped them understand the algorithm for dividing fractions.

The relationship between conceptual understanding and procedural fluency is not a simple sequence in which one type of knowledge is acquired before the other. Enhanced procedural knowledge can lead to better conceptual knowledge, and conceptual knowledge can contribute to improved procedural knowledge. (See sidebar.) A recent report by the National Research Council (Kilpatrick et al., 2001) stresses the interrelationship between procedural fluency and conceptual understanding of mathematics concepts:

> The two [procedural fluency and conceptual understanding] are interwoven. Understanding makes learning skills easier, less susceptible to common errors, and less prone to forgetting. By the same token, a certain level of skill is required to learn many mathematical concepts with understanding, and using procedures can help strengthen and develop that understanding. . . . On the other hand, once students have learned procedures without understanding, it can be difficult to get them to engage in activities to help them understand the reasons underlying the procedure. (p. 4-8)

In summary, having a curriculum that balances procedural fluency and conceptual understanding accomplishes several goals. First, it provides students with opportunities to learn the important concepts and processes of mathematics defined by standards. Second, developing understanding of underlying concepts, even those behind simple basic skills, helps students acquire more advanced knowledge and skills. Last, balancing the two makes it possible to take advantage of their interrelationship: development of one fosters development of the other.

Includes Important Content Knowledge & Process Skills

Closely related to the idea of balancing conceptual understanding and procedural fluency is comprehensiveness. A comprehensive curriculum includes the breadth and complexity of content and processes defined by NCTM standards and other national groups. NCTM (2000) describes its standards as "a comprehensive foundation recommended for all

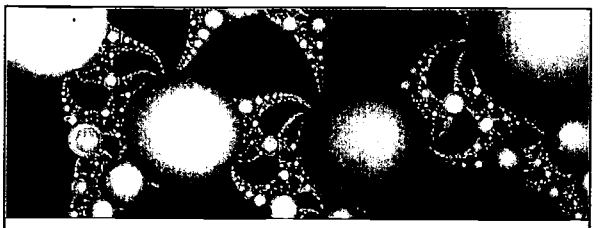
students, rather than a menu from which to make curricular choices" (p. 29). This means that if a district or school's mathematics curriculum focuses on only certain standards, student learning will be compromised.

Knapp, Shields, and Turnbull's (1995) study of high-performing, high-poverty schools found that curricula used by teachers of students who exhibited high computational and problem-solving abilities focused on more than just arithmetic. These curricula integrated additional strands of mathematics defined by standards – such as measurement, algebra, geometry, and data analysis – into instruction as a matter of course. Effective instruction, Knapp et al. conclude, emphasizes the development of knowledge and skills in *all* of the important areas of content and process.

Aligned with Standards and External Assessments

A study by the Charles A. Dana Center (1999) of high-performing, high-poverty, urban elementary schools in seven states found that alignment is another important characteristic of effective curricula. *Advancing Standards*, a publication produced by the National Education Association (McKeon, Dianda, & McLaren, 2001), describes alignment as "the process that ensures that learning activities focus on priority material, that teaching practices help all students reach learning goals, and that assessments illuminate ways to strengthen teaching and learning to meet standards" (p. 10). The process of alignment ensures that teachers teach the knowledge and skills that have been identified as important for students to learn (whether at the district or state level) and that are covered by external assessments. Curricula and instruction in the schools studied by the Dana Center were aligned with standards to ensure that students learned what they were expected to learn and what would be tested.

Similar findings were reported by the Education Trust (1999) based on its survey of 366 high-performing, high-poverty elementary and secondary schools located in 21 states. All of the schools surveyed were either (1) "high performing" – that is, they were among the 10 highest performing, high-poverty schools on state assessments in reading and/or mathematics; or (2) "most improved" – that is, they were among the 10 schools demonstrating the largest gains on state assessments in reading and/or mathematics. Eighty percent of these schools reported using standards extensively to design curricula and instruction.



Content and Processes Covered by a Comprehensive Curriculum

Content

- Number concepts
- Geometry
- Algebra
- Measurement
- Data analysis
- Probability

Processes

- Procedural fluency
- Reasoning
- Communication
- Problem solving

Teaching to High Math Standards: One Exemplary Teacher's Insights

Nyla Bristow doesn't have all the answers, and she wouldn't give them to her students at Christa McAuliffe Elementary School in Greeley, Colorado even if she did.

Instead, Bristow, who has been teaching for 25 years, prefers to solve problems together with her students. "Students need to see teachers modeling the process of thinking through problems and working them out," she says. Her reminder to other teachers is to remain flexible and willing to learn a variety of methods and that, "It's O.K. to start a lesson over again the next day."

Bristow is past president of the Colorado Council of Teachers of Mathematics and a recipient of the 1997 Presidential Award for Excellence in Mathematics and Science Teaching. As a lead teacher at her school, she encourages fellow teachers to stay open, be willing to use a variety of strategies, and above all else, keep expectations for students high. Recalling the challenges of an earlier nine-year stint at a school with a 50 percent Hispanic population and a high turnover rate, Bristow maintains that believing that all kids can "get math" makes a difference.

Teachers should set realistic goals for students, she thinks. Rather than trying to convince students to love math, energy is best spent instilling confidence in their ability to do math. One of the ways she achieves this in her classroom is to encourage discourse, making sure everyone has a chance to explain his or her thinking. She uses journals or student pairs to get students to express themselves and explore their ideas. She also likens the role of a teacher to that of a movie director — anticipating, monitoring, and adjusting.

After seeing too many students fail, Bristow was ready for change when standards-based reform was introduced and the emphasis in mathematics education shifted from being skill driven to application driven. "It is much more exciting to teach in a standards-based environment, but it also is much harder," she acknowledges. "Lecturing and checking answers to problems isn't as complex as teaching problem solving and asking open-ended questions," she explains.

Bristow notes that even though there are many good sources of standards-based mathematics materials, some teachers remain confused about standards-based approaches. For instance, planning an activity that uses manipulatives does not necessarily mean students are working towards achieving a particular standard. Teaching a process before students have mastered key concepts is also a pitfall, and many teachers need more guidance in using calculators and computers for instruction.

Coordinated & Coherent Within and Across Grades

Researchers have noted that in order to be effective, a standards-based curriculum should be coordinated across grade levels. In a coordinated curriculum, a standard receives different amounts of attention and addresses different levels of complexity at different grade levels. Teachers know what students need to learn in their current grade, but they also know what students learned in prior grades and what they'll need to be prepared to learn in future grades. Such coordination helps prevent instruction from being unnecessarily repeated and focuses instructional goals at each grade level. This reduces the sheer number of standards and benchmarks that teachers might otherwise feel compelled to cover and encourages in-depth coverage of content that is addressed.

A curriculum also should be coherent within a grade and within specific lessons. Within a grade, a coherent curriculum helps students see the connections between topics and big ideas. Within a specific lesson, a coherent curriculum develops and extends one central big idea. As the National Council of Teachers of Mathematics (2000) notes, a mathematics curriculum is coherent when it "effectively organizes and integrates important mathematical ideas so that students can see how the ideas build on, or connect with, other ideas, thus enabling them to develop new understandings and skills" (p. 15).

THE IMPORTANCE OF TEACHERS' KNOWLEDGE

McLaughlin and Talbert (1993) have concluded that in order for teachers to teach for understanding – a primary goal of mathematics education – they must have not only a deep understanding of the subject matter, but also a deep understanding of the best ways to convey this subject matter to students. They must also clearly understand

just how much their students have learned and understand about the material.

A recent analysis of 1996 NAEP data shows the importance of teachers' knowledge of mathematics content (Wenglinsky, 2000). Eighth-grade students of teachers who majored or minored in mathematics significantly outperformed other students on the NAEP exam.

Instruction that promotes students' understanding focuses on the meaning of material rather than the development of rote, procedural skills or the ability to regurgitate facts. According to Knapp, Shields, et al. (1995), "teaching for meaning" instruction has the following three properties:

- Helps students perceive the relationship of "parts" (e.g., discrete skills) to "wholes" (e.g., the application of skills to communicate, comprehend, or reason); . . .
- Provides students with the tools to construct meaning in their encounters with academic tasks and in the world in which they live; and . . .
- Makes explicit connections between one subject area and the next and between what is learned in school and children's home lives. (p. 771)

Teachers need support in order to learn how to instruct in ways that will enhance students' understanding and ultimately improve students' performance as measured against standards. To strengthen their ability to teach in this way, teachers need opportunities to collaborate and share information with their colleagues, and to learn through ongoing research-based professional development programs.

Teachers also need to understand and appreciate the diverse ways in which students learn and the unique perspectives and backgrounds their students bring to the classroom. Knapp, Adelman, et al. (1995) found that effective teachers of high-poverty students provided mathematics instruction that built on students' understanding and made connections to the world that students knew outside of the classroom.

Effective teachers also reported being more familiar with the populations of students in their classes. They explicitly acknowledged the diversity in their classrooms, and recognized and valued the strengths and knowledge of all students.

The importance of teachers' understanding individual differences also extends to students' evolving knowledge and skills. Teachers must also have the ability to determine what individual students know and understand. Ball (1997) maintains that figuring out what individual students know is not an easy task. She argues that this is difficult in part because students "do not represent their thinking in ways that match adult forms. They use nonstandard terms, draw pictures, and make analogies" (p. 735). Therefore, Ball explains:

> Interpreting what students mean involves considerable skill at listening, watching, and studying written work. . . . Listening across chasms of age, culture, and class, teachers face a problem common to most forms of cross-cultural communication. The problem is one of trying to understand what students mean with their words, pictures, gestures, and tone. (p. 735)

Ball also argues that determining what students know "involves generosity, giving them the benefit of the doubt, and skepticism, not assuming too much about what they mean" (p. 735). In addition, teachers need

to realize that students' understanding often depends on the context – "the particular task they are given . . . the adult who is asking them questions, and . . . the other students around them" (p. 736). Ball suggests that one strategy for gaining knowledge of what students know, understand, and are learning is for teachers to collaborate – to evaluate curriculum materials, to analyze student written work, to review videotapes of classroom lessons, and to observe one another's instruction.

Research demonstrates that when teachers better understand the development of students' mathematical thinking, students' performance is enhanced. For example, one widely studied teacher professional development program, Cognitively Guided Instruction (CGI), focuses on helping teachers better understand the development of students' mathematical thinking and, therefore, make better instructional decisions. A number of studies have shown that CGI students show significant gains in problem solving (see Carpenter, Fennema, Franke, Levi, & Empson, 2000). Students in CGI classes performed better on tests of problem solving than students in traditional classrooms and performed as well as students from traditional classes on tests of basic skills.

EFFECTIVE MATHEMATICS CLASSROOM PRACTICES

Curriculum plays a critical role in determining what students learn. But it is increasingly evident that instruction is every bit as important as content in helping students learn mathematics (Boaler, 2001; Cohen & Ball, 1999; Cohen, Raudenbush, & Ball, 2000).

This section reviews a number of the key practices that teachers can use with their students to help them learn important mathematics concepts and skills. Implementing any of these features individually or in combination does not necessarily guarantee that student learning will occur, however. As the Mathematics Learning Study Committee of the National Research Council (Kilpatrick et al., 2001) wrote in its report on developing mathematical proficiency, "No instructional practice, commodity, or material exists independently of context and

> ***When teachers better understand the development of students' mathematical thinking, students' performance is enhanced.***

participants as a durable and reliable resource for developing mathematical proficiency" (p. 9-44). In other words, these methods of instructing students in mathematics should be seen as part of a whole system geared toward helping students meet high standards.

Worthwhile Mathematics Tasks

Mathematics tasks are an important part of instruction because they represent the discipline to students and promote their learning of important material (NCTM, 2000; Hiebert et al., 1997; Kilpatrick et al., 2001). Worthwhile mathematics tasks have a number of characteristics, a few of which have already been touched on in this chapter. In this section, several additional characteristics are briefly highlighted:

- Require mathematical reasoning, problem formulation, and problem solving
- Require students to represent mathematics concepts
- Are accessible and of interest to all students
- Have multiple methods of solution

In addition, Hiebert et al. (1997) point out that it is important for tasks to be selected with learning goals or standards in mind. The mathematics learned through a task should connect with other knowledge that students have learned both within and across lessons so that students can develop and reflect on a coherent body of knowledge.

Although results from the 1996 NAEP teacher survey reveal that a high percentage of teachers assign textbook problems on a daily basis, fewer than 10 percent of fourth- and eighth-grade teachers have students write about how they solve those problems. As demonstrated in a study by Boaler (1997), teachers

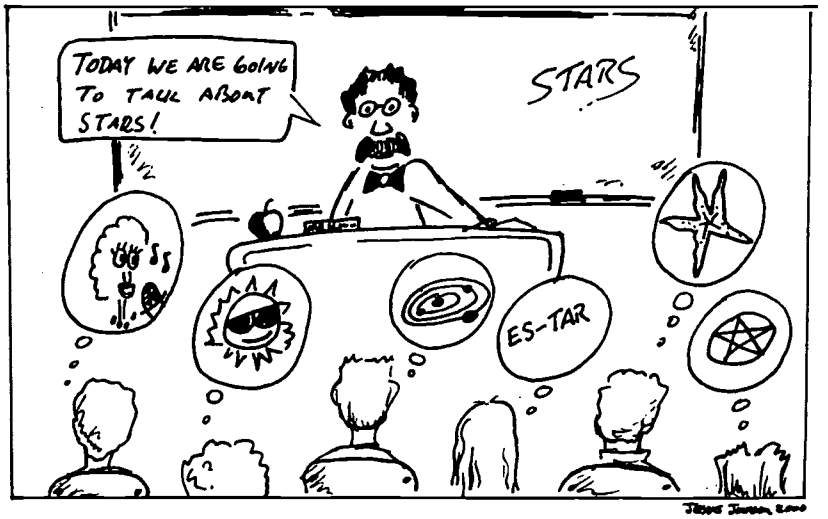
are not taking advantage of the instructional power of worthwhile mathematics tasks when they use problems in this way.

Boaler conducted a longitudinal study of two high-poverty secondary schools in England with different instructional approaches: One provided an open-ended, problem-based program; the other implemented a traditional, tracked, procedural-based program. After three years, achievement levels on national exams of the students attending the problem-based program were significantly greater, on average, than the achievement levels of students experiencing the traditional program. In addition, the achievement gap between students of high and low socioeconomic status decreased among students in the problem-based program – to the point that as a group, these students performed above the national average. In contrast, the achievement gap between these groups of students increased for students in the traditional program. Boaler (2001) concluded that not only should open-ended, problem-based mathematics programs be implemented for educationally disadvantaged students, but that implementing any program that is less demanding, such as one emphasizing procedural knowledge, is a disservice to such students.

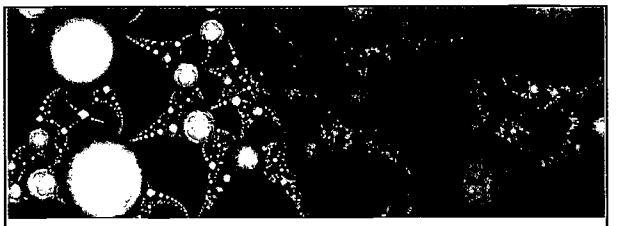
Tasks that require students to represent mathematics information contribute to classroom discourse focused on meaning. This is particularly true when students can decide what type of representation to use – for example, a graph, table, drawing, or equation.

A recent analysis (Hardy, 2001) of eighth-grade TIMSS video data of classrooms in Japan, Germany, and the United States illustrates this point. Tasks eliciting representations of mathematics information (e.g., "draw a square and label the parts corresponding to the parts of this binomial expression") were more likely to result in classroom dialogue about the meaning and connections between solution methods, symbolic systems, and mathematics concepts than problems requiring applications of concepts or routine tasks. In addition, representational tasks that were open ended with respect to the kind of representation used (e.g., "prove the relationship between the length of a triangle side and its opposite angle") resulted in more conversation about meaning than when the representation was pre-specified (e.g., "sketch the function's graph on the axes provided"). Tasks that require students to represent information, and to select their own mode of representation, contribute to classroom dialogue focused on meaning and student-constructed connections between solution methods, symbolic systems, or mathematics concepts.

Hiebert et al. (1997) write that tasks need to be accessible and of interest to all of the students in the classroom to maximize learning opportunities for everyone. For example, presenting a problem that requires students to determine how many passes a combine would have to make in order to harvest a field of wheat might require a short lesson on what a combine is before the problem might be understood by some students. Gender and diversity issues, which also affect the accessibility of tasks, should be considered when teachers are selecting or developing tasks. When these kinds of differences between students aren't taken into consideration, teachers might assume that students hold the same understanding of key terms, when in fact they don't, as illustrated in the cartoon below.



Note: Published in *Making Assessment Work for Everyone: How to Build on Student Strengths*, by the Assessment Laboratory Network Project of the Regional Educational Laboratories. San Francisco: WestEd. Copyright 2000 Jesse Johnson. Used with the permission of Jesse Johnson and WestEd.



Example of a Task with Multiple Solutions

Booker's Bakery sells cookies at these prices:

Oatmeal Cookies: 9¢

Peanut Butter Cookies: 12¢

Chocolate Chip Cookies: 15¢

1. What could you get in a $1.50 bag of cookies? Try to find several possibilities.
2. What is the maximum number of cookies you could get in a $1.50 bag?
3. Could you get a $1.50 bag of cookies with no chocolate chip cookies?
4. Could you get $1.50 bag of cookies with an equal number of all three kinds of cookies?

Note: From *Math Mountain*, by the Mid-continent Research for Education and Learning, March 1998, Aurora, CO: Author.

Similarly, researchers have found that mathematics problems that students can solve in different ways promote students' understanding. For example, Knapp, Adelman, et al. (1995) found that teachers in high-performing, high-poverty schools often used problems with more than one solution method and called for alternative solutions from students. To help students appreciate the complexity of these tasks, teachers did not emphasize typical solution strategies to problems or tout one strategy as more correct than another.

In summary, teachers' use of mathematics tasks that require students to integrate their knowledge and skills in new ways promotes students' achievement of standards. Teachers can help students stay engaged in such tasks by ensuring that the tasks appropriately build on students' prior knowledge. Further, teachers should provide enough time for thoughtful inquiry, model competent performance, draw connections among mathematics ideas and concepts, provide assistance to students in ways that maintain the complexity of a task, and sustain pressure for explanations and justifications from students. Finally, they should provide students with ways to monitor their own progress toward completing a task (Stein, Grover, & Henningsen, 1996).

Hands-On Experiences

Research supports the use of hands-on experiences, including manipulatives, physical models, and other concrete objects, as a tool for developing students' mathematics skill and understanding. For example, Reyes, Scribner, and Paredes Scribner (1999) studied high-poverty, Texas schools serving largely Hispanic students that exhibited above-average performance on the Texas Assessment of Academic Skills. Researchers found that elementary, middle school, and high school teachers regularly used manipulatives in the classroom for a variety of purposes – among them, to teach basic skills, to introduce students to concepts, and to give students concrete ways of seeing the concepts and skills involved in higher level thinking. The use of concrete objects also gave students practical examples of how and why mathematics is important to learn.

Similarly, research has found that frequent engagement in hands-on activities (such as working with blocks or models) increases students' performance. A recent analysis of 1996 NAEP data (Wenglinsky, 2000) found that eighth graders who were exposed to *weekly* hands-on learning experiences significantly outperformed students who were exposed to *monthly* hands-on activities.

The types of manipulatives teachers can use are vast. Blocks, flash cards, collages, counters, number displays, string, and straws, as well as games and puzzles, are just a few examples of the objects and tools teachers can use to teach basic skills and to help students understand mathematical concepts.

The use of physical materials in the classroom can extend students' prior experiences and knowledge of quantities. For example, teachers in the primary years

can take advantage of students' experiences with physical quantities (such as pails of sand, numbers of cookies, and the weights of books) to promote students' understanding of mathematics concepts. Another benefit of the use of physical materials in the classroom is that they provide a shared representation of mathematics concepts, which, in turn, can become a common experience for classroom discussion.

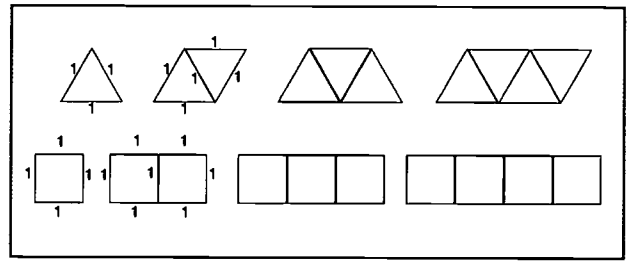
The mere use of manipulatives, however, does not necessarily lead to better student understanding of mathematics concepts. Assigning an activity just to keep students busy or using manipulatives without making connections to mathematics, for example, are strategies that aren't likely to lead to increased understanding. Knapp, Adelman, et al. (1995) documented ineffective uses of manipulatives among teachers who didn't see them as representations of mathematics ideas and, therefore, didn't understand how to use them to foster students' understanding. As the National Research Council (Kilpatrick et al., 2001) advises, teachers need to make explicit connections between concrete experiences, concepts, and symbols; when they don't, manipulatives become "just one more thing to learn rather than a process leading to a larger mathematical learning goal" (p. 9-41).

Meaningful Classroom Discussion

Engaging students in conversations in the mathematics classroom provides important learning opportunities for students. Hiebert et al. (1997) write about the important role that discussion can play in learning by creating "cognitive conflict." Cognitive conflict occurs when students encounter ideas that differ from their own in ways that cause them to rethink their understanding. Discussions are effective when students are confronted with contradictions, reevaluate their methods and ideas, elaborate and clarify their thinking, and reorganize their understanding. Peer interaction is especially effective at promoting cognitive conflict because the differences in thinking are likely to be within a range that generates genuine, fruitful conflict. In addition, when students are asked to orally justify their solution methods to their teachers and their peers, their own understanding deepens (NCTM, 2000).

Promoting Meaning Through Discussion

Mrs. Burns' eighth-grade students had been working on a problem about the perimeter of a chain of regular polygons formed by joining each polygon to the next along one side. So far the class had looked at triangles and squares and decided that they could represent the perimeter of a chain of joined triangles as n + 2 and a chain of squares as 2n + 2, where n refers to the number of polygons in the chain.



To extend students' thinking and to encourage them to re-evaluate their methods and ideas, Mrs. Burns asked students how they might represent the perimeter of a chain of regular polygons with 20 sides. Some students began by drawing a picture; others by making a table. When students had had a chance to think about the problem for a little while, Mrs. Burns asked for some ideas.

Alisha said, "I think the answer is 10n + 2 because 20 sides is 5 times as many as 4 sides and 5 times the 2n is 10n and you just add 2 to the end."

David said, "I think there's a pattern with the number in front of n. For triangles it was 1. For squares it was 2. I drew some pentagons and hexagons. For pentagons, it was 3, 3n + 2. For hexagons, it was 4, 4n + 2."

Tamara said she agreed with Alisha and David that the end part was always 2 but she wasn't sure why.

To help students elaborate and clarify their thinking, Mrs. Burns asked students to work with a partner to figure out the expression for 20 sides and be able to explain what each part of the expression represents. She circulated throughout the room, listening carefully to students' ideas, asking a probing question if a pair seemed stuck, and noting the various approaches students took to alert her to possible areas of confusion or enlightenment when the class continued its large-group discussion of the problem.

Note: Adapted from *What's Happening in Math Class? Envisioning New Practices through Narratives, Vol. 1*, edited by D. Schifter, 1996, New York: Teachers College Press.

> ***The point of classroom discourse is to develop students' understanding of key ideas.***

Professional Standards for Teaching Mathematics (NCTM, 1991) notes the pivotal role that teachers play in "orchestrating" classroom discourse in ways that help strengthen students' understanding of mathematics by

- posing questions and tasks that elicit, engage, and challenge each student's thinking;
- listening carefully to students' ideas;
- asking students to clarify and justify their ideas orally and in writing;
- deciding what to pursue in depth from among the ideas that students bring up during a discussion;
- deciding when and how to attach mathematical notation and language to students' ideas;
- deciding when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with a difficulty; and
- monitoring students' participation in discussions and deciding when and how to encourage each student to participate. (p. 35)

More and more teachers are creating opportunities for students to engage in classroom discussions, but these discussions are not necessarily productive discourse. Research suggests that higher level, complex discourse that helps deepen students' understanding is infrequent in mathematics classrooms. Several studies (see, e.g., Johnson, 2000; Koehler & Prior, 1993) reveal that on average, teachers' questions tend to elicit low-level responses from students rather than answers that require complex reasoning, explanation, or justification.

The National Research Council (Kilpatrick et al., 2001) reports on the potential for higher order discourse to promote student learning, noting:

> The point of classroom discourse is to develop students' understanding of key ideas. But it also affords opportunities to emphasize and model mathematical reasoning and problem solving and to enhance students' disposition toward mathematics. Therefore, discourse needs to be planned with these goals in mind, not merely as a "checking for understanding" form of recitation. (p. 9-32)

Because social interaction is rarely taught explicitly in mathematics classrooms, clear ground rules for classroom discourse need to be established and maintained. Hiebert et al. (1997) conclude that the following are important social norms for classroom discussion:

- Discussions are about methods and ideas.
- Students choose their own methods and share them with others.
- Mistakes are sites for learning.
- Correctness is determined by the logic of mathematics.

Researchers (e.g., Grouws & Cebulla, 1999) who have studied the use of whole-class discussion in mathematics classrooms conclude that this method provides an opportunity for teachers to assess students' understanding and identify misconceptions, but caution that this method works best when students clearly understand the expectations for classroom discourse. For example, students should be expected to evaluate one another's ideas and reasoning, without being critical of one another as individuals. Engaging in productive discussions with other students can help struggling students learn from their peers and help high-performing students gain an even deeper understanding of mathematics concepts in their efforts to explain them to other students.

To reap these benefits, teachers must actively manage discourse in the classroom by focusing discussion on

worthwhile mathematics tasks and relying on mathematical evidence to determine the validity of arguments and conclusions. They should engage students in reflective discussion about the process of doing mathematics and ask questions that promote students' analysis of mathematical situations or problems.

Supportive Technology

Research suggests that calculators and computers can be effectively used as tools for solving mathematics problems and promoting discourse about important concepts (NCTM, 1991). Leading standards documents and curriculum frameworks recommend the use of these and other technologies in instruction (AAAS, 1993; Robitaille et al., 1993; NCTM, 2000). However, because they can be ineffective if not used appropriately, it is important to understand how teachers should and should not use these tools in the classroom to promote student achievement.

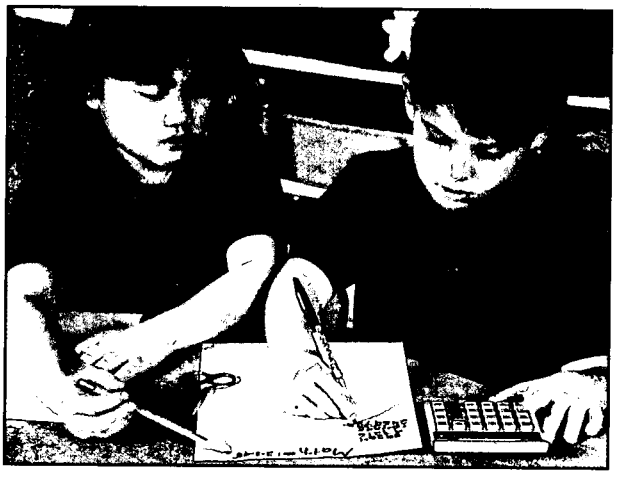
Calculators

In spite of long-standing concerns about the use of calculators by precollege students, calculators can be successfully integrated into instruction to help students learn important content and processes. The National Council of Teachers of Mathematics (1998), in its "Calculators and the Education of Youth" position statement, "recommends the integration of calculators into the school mathematics program at all grade levels" (p. 1), noting:

> Appropriate instruction that includes calculators can extend students' understanding of mathematics and will allow all students access to rich problem-solving experiences. Such instruction must develop students' ability to know how and when to use a calculator. (p. 1)

Research on the effects of calculators on students' computational and problem-solving skills is generally positive. One large study was undertaken by Hembree and Dessart (1992). Based on their meta-analysis of 88 research studies, these researchers found that "the preponderance of research evidence supports the fact that calculator use for instruction and testing enhances learning and the performance of arithmetical concepts and skills, problem solving, and attitudes of students" (p. 30). A study by Grouws and Cebulla (1999) notes that "teachers ask more high-level questions when calculators are present, and students become more actively involved through asking questions, conjecturing, and exploring when they use calculators" (p. 129).

Studies of students using graphing calculators report similar findings. These students develop enhanced graphing abilities, representational skills, problem-solving abilities, mental flexibility, perseverance, and conceptual understanding compared to students who do not use graphing calculators. In addition, most studies of graphing calculators have not found negative effects on basic skills, factual knowledge, or computational skills (Grouws & Cebulla, 1999).



On the other hand, an analysis of 1996 NAEP and 1994–95 TIMSS data of fourth graders' achievement conducted by the Brown Center for Education Policy (Loveless & Dipnera, 2000) found that students who reported using calculators every day in the class had the lowest test scores compared to students who reported using calculators "never," "once or twice a month," or "once or twice a week." But Loveless and Dipnera caution against drawing the conclusion that calculator use causes low achievement, noting, "Low student achievement may just as easily 'cause' calculator use as the other way around" (pp. 22–23). In fact, they note, the negative correlation between calculator use and NAEP scores was not found when teachers were asked how frequently their students use

calculators. Teachers who reported that their students used calculators every day had students with high test scores.

The ways in which calculators are used may be more important than whether they are used. For example, at the elementary level, the availability of calculators in classrooms may help put the instructional emphasis on problem solving or mental arithmetic. In later grades, calculators can be used as a tool to explore mathematics, which can enhance the level and complexity of mathematics instruction that occurs in the classroom.

Computers

Research findings related to students' use of computers are mixed. Some studies have found that software that encourages high-level thinking skills can promote learning. For example, an Education Trust (1998) study reports that high achievement is associated with frequent exposure to computer simulations and other high-level applications. However, the study found that using computers for drill-and-practice exercises was negatively correlated with achievement. These findings are particularly disturbing in light of other findings related to the types of computer use that various groups of students experience. Specifically, the study found that African American students were more than twice as likely as white students to use computers for drill-and-practice of basic skills, while white students were more than twice as likely to use software addressing higher order thinking about mathematics.

Research suggests that special populations can benefit from instruction that integrates the use of computers and other technologies. For example, Reyes et al. (1999) found that high-performing, high-poverty Texas schools commonly used computer programs to assess students' mastery of mathematics content or objectives, to reteach or strengthen certain mathematics skills, and to diagnose weaknesses in ways that could be used to develop individualized student learning plans. Reyes et al. report that the most effective teachers supplemented computerized programs with instruction that had the following three features:

- Emphasis was placed on meaning and understanding.
- Mathematical skills were embedded in context.
- Connections were made between subject areas and between school and life outside of school. (p. 125)

Reyes et al. also report that computerized instruction was learner centered and interactive:

> Teachers and students collaborated and interchanged roles from learner to expert and vice versa. . . . In short, technology was used as a catalyst for change and as a tool for creating, implementing, managing, and communicating a new conception of teaching and learning. . . . In the process, basic skills in mathematics were learned as well or better through these alternative instructional approaches. (p. 125)

Taking advantage of access to the Internet is another way that teachers can use technology to make their classroom practices more learner centered. Through the Internet, students are able to pursue activities and information that interest them and at some sites can access well-designed activities on specific mathematics topics. In this way, the Internet enhances students' motivation and learning.

Unfortunately, high-poverty schools frequently encounter barriers when trying to integrate technology into instruction. First, these schools are more likely than others not to have access to the

Internet, other advanced telecommunications applications, or software that is aligned with the curriculum (Education Week, 2001b). Second, these schools often lack technical support and adequately trained staff for integrating technology into instruction. A recent national survey revealed that only 10 percent of teachers felt "very well prepared" to use technology in the classroom, and an additional 23 percent rated themselves as "well prepared" to use technology in instruction. Most teachers (53%) rated themselves as only "somewhat prepared" (National Center for Education Statistics, 2001). Therefore, even though some kinds of computer software can enhance students' learning, teachers' knowledge and skill in using technologies can be barriers to using these resources effectively.

In summary, research about the use of calculators and computers suggests that these tools can help develop students' understanding of mathematics. Teachers may need support in learning how to move beyond using these tools primarily for drill and practice.

Using Assessment Data to Guide Instruction

Teachers use various types of classroom assessments, including informal questioning, open-ended or constructed-response items, project-based assessments, portfolio assessments, multiple choice tests, oral assessments, and so on. Different types of assessments are appropriate depending on the knowledge or skill being assessed and individual students' needs and learning styles. Regardless of the type of assessment used, feedback from assessments can provide teachers with valuable information about students' progress.

Research findings demonstrate that effective teachers know how to use assessment information to adjust their teaching to students' needs. For example, a meta-analysis by Black and Wiliam (1998) of 43 studies of assessment innovations found that programs that strengthened teachers' abilities to use assessment information to monitor learning and guide instruction resulted in substantial gains in learning. This use of assessment was found to be particularly effective with lower achieving students.

Similarly, Reyes et al. (1999) found that teachers at high-performing, high-poverty Texas schools regularly assessed students' progress and used assessment information to guide future instruction.

> ***"Feedback from assessments can provide teachers with valuable information about students' progress."***

Both formal and informal assessments were used. These assessments took a variety of forms, which varied somewhat between elementary, middle, and high schools, including observations of individual and group work during class, oral assessments, homework assignments, one-on-one questioning of students, computer-based assessments aligned with state standards, student presentations of homework, and portfolios and projects. This wide array of assessments gave teachers information about students' strengths and needs, which they used to adjust instruction and to provide feedback to students and parents about students' progress.

Gathering information from both formal and informal assessments is a critical aspect of ensuring that instruction is targeted and adjusted to best meet students' learning needs – and to help keep students from falling behind. An Education Trust study (1999) found that among other strategies, high-performing schools tended to "implement comprehensive systems to monitor individual student progress and provide extra support to students as soon as it's needed" (p. 3). In fact, the study notes that 81 percent of the top-performing, high-poverty schools had such systems in place. This "safety net" approach to helping students who are in danger of falling behind can include adjusting instruction, providing individual or group tutoring sessions, and providing regular reports to parents so they can support their children's learning.

In summary, research suggests teachers should use a variety of classroom assessments to gauge students' learning and adjust instruction to meet students' needs. An assessment system that monitors learning

should be implemented in order to identify students who are low achieving and provide them with adequate instructional time and resources.

CONCLUSIONS

Standards documents developed by national professional groups set out a vision of the important knowledge and skills that students should acquire and apply in mathematics. These standards cover a range of content and processes and set the bar high for student learning. Research indicates that current classroom practice does not always provide students with the opportunities they need to acquire the depth and breadth of knowledge and skills identified in standards. The situation is worse for high-needs students who are more likely to have less qualified teachers and for whom expectations have been traditionally low.

One area in which to begin to address this problem is curricula. Research findings make a strong case for providing students with curricula that are balanced in their focus on developing conceptual understanding and procedural fluency. Curricula should be comprehensive, addressing all the content knowledge and processes defined by standards. Curricula that support standards should be specified across grade levels in order to focus instruction and reduce repetition within and across grade levels. Curricula should also be coherent, relating content and process skills within and across grades.

Research also provides guidance about the types of knowledge that teachers need and characteristics of instructional practices that are effective in helping students, including high-needs students, achieve the levels of learning outlined by numerous standards documents now available. To help students acquire the depth and breadth of mathematics content and processes defined by standards, teachers need to develop their own understanding of important mathematics concepts. It's also critical for teachers to know the common conceptions and misconceptions that students have as they learn about mathematics – and know how to use instructional strategies to address these. Teachers must also know how to gauge students' progress in learning targeted mathematics content and skills. In addition, it's important for teachers to understand and draw on students' diverse backgrounds and experiences to make learning mathematics accessible and relevant.

Teachers also need to know how to select and use a variety of assessment methods to determine the degree to which students have acquired the targeted knowledge. Studies indicate that, in addition, teachers should know how to use assessment for formative purposes – to make appropriate adjustments to instruction for individual students or for groups of students. When they do so, students' performance is likely to improve. Formative assessment should also occur at the school level; assessment systems should be designed to frequently monitor students' learning in order to provide early support to students who are struggling.

Teaching has always been a complex endeavor, but the expectation that all students will achieve high standards has greatly increased its complexity. Although research about instruction may not decrease the complexity of the task, it does provide examples of practices that have helped students reach high standards. In order to ensure that all students achieve the levels of mathematics learning embodied in standards, it's important to share these approaches widely and provide teachers with the support they need to learn and apply them.

Chapter 4 SUPPORTING INSTRUCTIONAL CHANGE

In recent years, an increasing body of research has begun to illuminate the wide-reaching effects of standards-based education practices. In spite of the differences in questions posed by different researchers, a number of common themes are emerging about the approaches, strategies, and characteristics of teachers and learning environments that positively influence students' learning.

A commitment to ensuring that all students achieve at high levels was one of the original principles that spawned the standards movement in the 1980s. That commitment is still widely shared and remains firmly at the center of reform efforts across the country. But in spite of this worthwhile goal, the achievement gap between students performing at proficient levels and those failing on standardized tests persists. Clearly, much work still needs to be done to reach these students and others in danger of falling behind.

The content areas judged to be most vital to students' success in school and in life are reading, writing, and mathematics. These core areas are emphasized in standards documents across the country and are the focus of most high-stakes district- and state-level accountability systems. If students don't have the fundamental skills of reading for understanding, communicating clearly in writing, and aren't able to use and apply critical mathematics knowledge in their personal and work lives, their chances for success are greatly diminished. For these reasons and more, the development of reading, writing, and mathematics understanding and skill must be of primary importance to parents, teachers, administrators, and, indeed, business, community, and political leaders as well.

Research studies cited in this issue of *Noteworthy* provide guidance and strategies for enhancing students' learning in reading, writing, and mathematics. In order to implement these strategies, local educators need to have a great deal of capacity – often much more than they currently possess. Schools and districts need to focus their resources, energy, and attention on developing that capacity among their staff by providing ongoing opportunities for quality professional development.

Although adequate resources are crucial to school success, knowing how to use the resources that are available is perhaps even more crucial. Many schools, of course, operate with limited resources. It is all the more important for these schools to spend what limited financial resources they do have wisely – in other words, to figure out how to get the biggest bang for their buck.

PROFESSIONAL DEVELOPMENT FOCUSED ON STANDARDS

One thing we know quite clearly from research is that teachers have a profound impact on student achievement – for good or ill. An example is the often cited work of Sanders (1998), which showed that students of effective teachers in Tennessee posted impressive gains in achievement on state assessments, while students of ineffective teachers continued to fall farther behind their peers – as much as a year or more.

Standards-based reforms require teachers to deepen their knowledge and strengthen their skills in a number of areas. Research emphasizes that teachers need the following to be effective in standards-based classrooms:

- A belief and expectation that all of their students will meet high standards
- Knowledge of a subject area and its connections to other fields
- Knowledge of how to represent subject matter to students, including an understanding of the learning process and areas in which students may struggle (pedagogical content knowledge)
- A repertoire of instructional strategies that balances higher order interactive teaching with didactic skills instruction
- Knowledge of how differences among students in areas such as culture, language, gender, and economic status relate to learners' frames of reference

Studies of teaching in subject areas such as reading, writing, and mathematics have concluded that subject knowledge matters. Researchers, such as Shulman (1986), also have concluded that teachers need pedagogical content knowledge – a deep understanding of how best to represent the core ideas of a subject to students. This includes understanding the common mistakes that students make when learning a subject.

> ***When staff development is connected to subject matter, it has much more impact on student achievement than more generic approaches.***

The impact that teachers have on student achievement and the need for teachers to gain new skills to be effective in standards-based classrooms make a strong case for focusing available resources on professional development. It's not surprising, then, that an Education Trust (1999) survey found that the highest performing, high-poverty schools spend a large proportion of Title I dollars on professional development. Respondents to the survey noted, however, that the key issue is not how much money is invested in professional development, but, rather, making sure that staff development efforts are focused on implementing standards in view of students' needs. Simply providing more staff development doesn't ensure high levels of student achievement. Instead, funds must be spent to design a staff development program that is tailored to specific issues related to student achievement. For example, aligning classroom assessments with school standards, identifying individual students' level of understanding and skill on specific standards, and grading in a standards-based classroom are all important targets of professional development.

One of the most salient points to emerge from recent research is that in order to improve teachers' capacity to teach in standards-based classrooms, the content of professional development must be directly linked to the curriculum teachers are implementing in their classrooms. A growing body of research shows that when staff development is connected to subject matter, it has much more impact on student achievement than more generic approaches divorced from the actual curriculum being used.

For example, Cohen and Hill (1998) studied the influence of professional development in mathematics on the classroom practices of a random sample of 1,000 California teachers in grades two through five. Teachers who spent more time in curriculum workshops as opposed to special topics workshops reported using more instructional practices that were aligned with the mathematics curriculum than teachers who spent more time in topical workshops. Moreover, schools with higher proportions of teachers participating in curriculum-centered professional development had higher student achievement scores on the state math test.

In a related vein, there have been several reports about the use of subject-based professional development in New York City's District 2. Based on interviews with teachers, Stein and D'Amico (1999) found that elementary teachers had different subject-area knowledge and pedagogical content knowledge in mathematics compared to literacy. This finding

supported the district's use of subject-oriented approaches to professional development. In a subsequent study of District 2, D'Amico, Harwell, Stein, and van den Heuvel (2001) found positive relationships between teachers' perceptions of the quality of professional development and students' achievement in literacy and mathematics.

It seems clear that professional development can profoundly influence the extent to which teachers effectively bring standards-based reform to life in their classrooms and, in turn, increase student achievement. However, in order to positively influence teachers and students, professional development opportunities must focus on the actual content – indeed, the actual standards – that teachers are using in their classrooms. Moreover, it is important that student performance scores be used to focus professional development efforts on those standards where students are in most need of improved instruction.

THINKING SYSTEMICALLY ABOUT IMPROVEMENT

Creating truly effective, standards-based schools, of course, takes time. Many of the high-performing, high-poverty schools discussed in recent research studies report that their improvement efforts took years to accomplish – in some cases, a decade. Furthermore, despite the accolades they are receiving, most of these schools still consider themselves to be in the midst of a continuous improvement process and acknowledge that they still have much room to improve.

Indeed, no single element of successful schools or effective teaching on its own is capable of creating a system in which all students meet high standards for learning. All of these elements must be combined in a coherent fashion to ensure success for all students. As Nebraska's Commissioner of Education Doug Christensen puts it:

> If X = Everything schools need to do to be successful, then X - 1 = 0.

In other words, educators need to keep all aspects of the system in mind as they go about improving their schools. Schools are communities and, like most communities around the world, they include diverse views and children with differing strengths and weaknesses. Teachers need strong, knowledgeable leaders who empower others to share leadership tasks, time for sharing ideas and learning from one another, and resources to assist them in reaching their goals. All of these elements need to be centered around a guiding vision that is shared and a commitment to do what it takes to ensure the success of every child.

SHORT-TERM SCHOOL IMPROVEMENT STRATEGIES

Although ensuring the success of every child may occur over a period of years, educators are keenly aware that children can't afford for us to take years to improve the quality of their learning experiences. Every year can become yet another year during which they fall farther behind and see their chances for life success further diminished.

Although it is important for educators to map out an improvement strategy for the long term, they must also adopt changes along the way that have been proven to have profound and immediate results. With this in mind, the following recommendations are made to schools and districts:

- Align curricula and assessments with standards.
- Provide time and resources for systematic phonics instruction prior to second grade.
- Provide oral reading practice and opportunities for silent reading accompanied by discussion.

- Ensure that classroom practices targeting development of each of the component skills of literacy are integrated into a comprehensive reading program.
- Give students daily opportunities to read and write.
- Provide extended writing time for students to plan, refine, and hone their work.
- Develop students' conceptual understanding as well as their procedural and computational fluency.
- Use accessible tasks that require students to represent mathematical concepts and use mathematical reasoning, problem formulation, and problem-solving skills.
- Engage students in conversations about their reading and writing and in discussions focused on mathematics ideas.
- Use calculators and computers in mathematics classrooms when appropriate.
- Use feedback about students' performance from multiple sources to guide and revise instruction.
- Provide extended learning opportunities for students who are struggling.
- Invest in professional development that strengthens teachers' content-area and pedagogical knowledge and skills.

This list by no means represents a complete formula for success. But it's difficult, if not impossible, for improvement efforts to begin everywhere at once. Research findings suggest that these changes may be good places to begin.

STANDARDS-BASED REFORM VS. TEST-BASED REFORM

As noted earlier, the current backlash against standards appears to be less of a backlash against standards and more of a backlash against the way they are being used. Concerns are being raised about using standards to foster "test-based reform" rather than real changes in instruction.

For example, a growing number of studies are examining state-level writing assessments and the effect they are having on teaching and learning.

After analyzing writing samples, interviewing students, and conducting classroom observations, researchers Ketter and Pool (2001) concluded that instruction that is developed around test-like prompts narrows conceptions of writing, and consequently, the range of skill, strategy, and genre exposure. Similarly, researchers (Center for Educational Policy Analysis [CEPA], 2001) found that New Jersey's fourth-grade mathematics test, Elementary School Proficiency Assessment, prompted teachers in high-poverty districts to spend nearly twice as much time teaching test mechanics and using commercial test preparation materials than did teachers in low-poverty districts.

A study of a Pittsburgh school where 79 percent of students performed at the 51st percentile or better on a high-stakes, norm-referenced test found that when students were given a different exam, fewer than five percent demonstrated mastery of basic skills or problem solving. Researchers concluded that high-stakes assessments "either promote reform and lead to increased math learning by all students or they undermine reform and produce ill-prepared students who get high test scores. It all depends on the test that is selected and how it is used" (Briars, 1999, p. 32).

A central question is whether such assessments truly drive the kinds of changes that matter – namely, positive instructional changes in the classroom. On this question, research findings are mixed. On the one hand, a study of the impact of Maine's and Maryland's mathematics performance assessments on instruction revealed that teachers did not change their fundamental methods of instruction in response to the programs (Firestone, Mayrowetz, & Fairman, 1998). Although teachers changed the order in which they taught content areas in mathematics, they did not change their actual teaching practices very much. Firestone et al. concluded that teachers "lack the deep understanding of mathematics to teach in ways that help students learn to reason mathematically while calculating accurately. Teachers also need to better understand how students make sense of and learn from mathematical problems" (p. 112). These researchers concluded that high-stakes accountability systems alone are not effective mechanisms for changing instruction.

On the other hand, some research findings suggest that external assessments can positively influence student learning. For example, CEPA's (2001) study of New Jersey's Elementary School Proficiency Assessment revealed that including open-ended questions on the exam prompted teachers to ask students to explain their thinking and emphasize problem-solving more often. Still other researchers have found that state assessment and accountability pressures have caused teachers to put more thought into individual school writing programs, and to strive for a consistency of goals across grade levels. Some teachers have also reported that standards-based reforms in writing have caused them to expand their writing programs to include more forms of writing.

BENEFITS OF STANDARDS

On the surface, standards appear to be a simple proposition – identify what students should know and be able to do, and then teach this to them. But as educators and policymakers have discovered, creating a system that joins high standards with high expectations for all students and provides students with the necessary support to meet those standards has been an enormous and frustratingly complex undertaking.

Mixed research findings about the effects of standards are a reflection of that complexity and the fact that standards have been implemented, and even thought of, in different ways. The emphasis on testing and high-stakes accountability has caused many educators to feel like we've lost the original purpose of the standards movement – ensuring that all students are capable of meeting high expectations for learning.

> ***"The challenge to educators is to ensure that classrooms become supportive environments where real learning occurs."***

At the same time, it's important to note that these efforts to implement standards in our nation's classrooms – indeed the very thing that educators have grown to love to hate, high-stakes testing – have brought about some positive changes in high-poverty schools. As the Dana Center and the Education Trust have both pointed out, there are a number of high-performing, high-poverty schools that have been successfully operating under high-stakes testing and tough accountability systems.

Granted, lingering questions remain about whether the changes being observed in these schools are all beneficial to students. Nevertheless, it is apparent that change is occurring. So the challenge to educators is to make sure that these changes are positive changes – to ensure that classrooms simply do not become test preparation factories, but rather become supportive environments where real learning occurs.

THE FUTURE OF STANDARDS

As some have noted, standards and accountability are probably not going away any time soon. And others have asked what we'd be left with if standards and accountability did go away:

> Few analysts have considered the fundamental question: If standards and testing disappeared tomorrow, what would be the alternative? To hear the critics of standards and tests, the answer would be educational paradise. Such an assumption rests upon the faith that, absent standards and testing, every classroom would offer expectations that were clear, rigorous, and objective. (Reeves, 2001, p. 52)

Reeves and others have argued that we should not retreat from standards-based reform, since doing so would most likely mean retreating from the notion of holding high expectations for all children. And as this edition of *Noteworthy* has shown, children can achieve high standards in core areas like reading and math, when they are given the necessary support and offered effective learning environments.

Unquestionably, creating true standards-based classrooms requires much more than simply saying, "all children can learn" and expecting it to happen. It requires a great deal of effort and resources to change how teaching and learning occur in our classrooms. It requires the expectation that all students can achieve high standards if educators use effective research-based practices. These changes are not only possible, they are beginning to happen in classrooms all across the country.

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